EVALUATION OF COMPLEX WORKPLACE DIETARY INTERVENTIONS

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LIST OF ABBREVIATIONS

ABBREVIATION	TERM
BMI	Body Mass Index
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis
CEAC	Cost Effectiveness Acceptability Curve
CMAI	Catering Managers Association of Ireland
CPI	Consumer Price Index
CSO	Central Statistics Office
CUA	Cost Utility Analysis
DALY	Disability Adjusted Life Years
DASH	Dietary Approaches to Stop Hypertension
FCW	Food Choice at Work Study
FFQ	Food Frequency Questionnaire
GDP	Gross Domestic Product
HIQA	Health Information Quality Authority
HR	Human Resources
HRB	Health Research Board
HTA	Health Technology Assessment
IBEC	Irish Business and Employer's Confederation
ICER	Incremental Cost Effectiveness Ratio
IDA	Industrial Development Authority
IPHA	Irish Pharmaceutical Healthcare Association
MGI	McKinsey Global Institute
MRC	Medical Research Council
NANS	National Adults Nutrition Survey
NCD	Non-communicable diseases
NHS	National Health Service
PRSI	Pay Related Social Insurance
PSA	Probabilistic Sensitivity Analysis
QALY	Quality Adjusted Life Year
QNHS	Quarterly National Household Survey
RCT	Randomised Controlled Trial
SD	Standard Deviation
SFA	Small Firms Association
SLÁN	Survey of Lifestyle, Attitudes and Nutrition
SOP	Standard Operating Procedures
UK	United Kingdom
UN	United Nations

US	United States
VIF	Variance Inflation Factor
WHO	World Health Organisation
YLD	Years Lived with Disability
ZINB	Zero Inflated Negative Binomial

DECLARATION

I declare that this thesis has not been submitted for another degree at this or any other University. The work, upon which this thesis is based, was carried out in collaboration with a team of researchers and supervisors who are duly acknowledged in the text of the thesis. The library may lend or copy this thesis upon request.

Signed: Date:

_________________________ _________________________

DECLARATION OF AUTHORSHIP

The candidate has taken responsibility for all aspects of the work presented in the thesis from its inception. For Chapter 3, 'Obesity, diet quality and absenteeism in a working population', the candidate developed the study design, along with guidance from Professor Ivan Perry, Dr Ann Kirby, Dr Aileen Murphy and Dr Fiona Geaney. The candidate was responsible for data analysis and construction of the count model while Dr Ann Kirby and Dr Aileen Murphy supervised analysis. The candidate was the lead author for the related publication.

For the process evaluation outlined in Chapter 4, the candidate received guidance from Dr Sheena McHugh and Dr Ivan Perry with regards to the study design. The candidate was responsible for data collection along with Dr Fiona Geaney and Ms Clare Kelly. The candidate was primarily responsible for data analysis with Dr Sheena McHugh acting as the inter-rater during data analysis and also as the moderator of the focus groups. The candidate was the lead author on the related publication and was responsible for its final content.

The candidate worked on the study design of the cost-analysis presented in Chapter 5, with guidance from Dr Ann Kirby and Dr Aileen Murphy. The candidate was responsible for micro-costing and data analysis, while Dr Ann Kirby and Dr Aileen Murphy supervised analysis. Dr Fiona Geaney and Professor Ivan Perry provided interpretive input of the cost analysis. The candidate was lead author on the related publication. For the economic evaluation presented in Chapter 6, the candidate worked with Dr Aileen Murphy and Dr Ann Kirby on the study design and methods. The candidate carried out data analysis and ran the Monte Carlo simulation model in Microsoft Excel with supervision from Dr Aileen Murphy. The candidate was the lead author on the publication which has been submitted to the BMJ. The candidate wrote this thesis with supervision from Professor Ivan Perry, Dr Ann Kirby, Dr Aileen Murphy and Dr Fiona Geaney.

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THESIS ABSTRACT

Background and aim

The workplace has been identified as an ideal setting in which to promote healthy dietary behaviours. However, uncertainty surrounds both the effectiveness and cost-effectiveness of workplace dietary interventions and a dearth of evidence exists with regards to evaluating the implementation process of such interventions. The core aim of this thesis was to conduct both a process evaluation and an economic evaluation of the Food Choice at Work (FCW) complex workplace dietary intervention.

Methods

The FCW study was a pragmatic trial which measured the effectiveness of a complex workplace dietary intervention in ideal settings. Firstly, a cross-sectional analysis which employed a zero-inflated negative binomial (zinb) regression model to examine associations between objective health status outcomes, lifestyle characteristics and absenteeism was conducted. Secondly, a detailed process evaluation addressed the implementation of the complex workplace intervention. Interviews were conducted at baseline (27 interviews) and at 7-9 months follow-up (27 interviews) with a purposive sample of workplace stakeholders (managers, caterers and employees). Data were analysed using a thematic framework. Thirdly, micro-costing methods were employed to estimate the cost of implementing and delivering the complex workplace dietary intervention from an employer's perspective. Finally, an economic evaluation of the complex workplace intervention was conducted. This consisted of 1) a baseline cost-utility analysis (CUA) which measured the cost-effectiveness of the interventions in terms of quality-adjusted life-years (QALYs), 2) sensitivity analyses to test the robustness of the QALYs which involved performing cost-effectiveness analyses (CEA) using clinical measures to measure health outcomes and 3) a cost-benefit analysis (CBA) where the monetary value of absenteeism was employed so as to report the net benefit of the interventions relative to the control.

Results

Central obesity was positively associated with absenteeism and increased the expected rate of absence by 72% (mean number of absences was 2.5 days). Consuming a high-quality diet and engaging in moderate levels of physical activity were negatively associated with absenteeism and reduced the expected frequency by 50% and 36% respectively. The process evaluation revealed that managers' desire to improve company image, stakeholder buy-in, organisational support and stakeholder cohesiveness facilitated the implementation of the interventions. Anticipation of employee resistance towards menu changes, workplace restructuring and target-driven workplace cultures were found to impede intervention implementation. With regards to the cost-analysis, 3 main cost categories were identified 1) set-up costs 2) maintenance costs and 3) physical assessment costs. The combined intervention

reported the highest total costs (€47,305), followed by nutrition education (€44,726), environmental modification (€24,474) and the control (€21,412). In the economic evaluation, the baseline CUA indicated that each intervention (education (€970/QALY) environment (€98/QALY) and combined (€2,156/QALY)) can be considered cost-effective when compared to the control. The CEACs demonstrated that the uncertainty in the incremental costs and effects translated into decision uncertainty for the environment intervention (50% probability of being cost-effective at €45,000/QALY threshold). However, at no point between a ceiling ratio of €0 to €100,000/QALY did the education and combined interventions have a higher probability of being cost-effective than the control. The results of the secondary CEA confirm the baseline CUA results for each intervention. The environment intervention reported the lowest ICERs for: BMI (€14/kg/m^2), midway waist circumference (€3/cm) and weight (€7/kg). Furthermore, the environment intervention offers the highest net benefit for employers with a positive net benefit of €145.82 per employee reported.

Conclusion

This thesis provides critical evidence on the relationship between obesity, adverse lifestyle factors and absenteeism. Furthermore, findings also indicate that environmental modification strategies have the potential to offer a cost-effective approach for improving employee health outcomes, depending on the perspective taken. This thesis also highlights the importance of considering contextual factors such as workplace structures and cultures in the development and implementation of future workplace dietary interventions.

1. THESIS SUMMARY

1.1. Introduction

The growing prevalence of chronic diet-related diseases remains one of the leading global public health challenges. The associated burden of diet-related diseases endangers not only population health but also the sustainability of healthcare systems worldwide (1, 2). Obesity and other diet-related diseases such as cardiovascular disease and stroke have also been linked to absenteeism in the workplace, incurring substantial costs for both employers and societies (3, 4).

In an effort to ease this cost escalation, workplace health promotion has moved to the forefront of organisational agendas, with employers investing in an array of workplace wellbeing initiatives (5, 6). Moreover, given that employees are now spending increasingly longer hours in their work environments, the workplace has been identified as a priority setting for the promotion of healthy dietary behaviours (5). However, to date a great deal of uncertainty surrounds the effectiveness of workplace dietary interventions. Linked to this issue of effectiveness, there is a growing appreciation for the need for rigorous evaluation of the implementation process to investigate the equivocal findings and to explore why these interventions are having such limited effects (7-9). For instance, the Medical Research Council (MRC) have advocated combining evaluations of processes with that of evaluations of effectiveness (10). In addition, to the uncertainty surrounding effectiveness and the lack of evidence regarding the implementation process, a paucity of evidence exists regarding the cost-effectiveness of workplace dietary interventions (8, 11, 12). This thesis focuses specifically on evaluating the implementation process of a complex workplace dietary intervention and also analysing its cost-effectiveness.

1.2. Overall aim and objectives

The primary aim of this thesis was to conduct a process evaluation and an economic evaluation of complex workplace dietary interventions.

In particular, the objectives were to:

1. Investigate if health status outcomes and lifestyle characteristics influence the frequency of workplace absenteeism, using objective measures for both absenteeism and health status outcomes.
2. Define and explore barriers to and facilitators of implementing complex, high-intensity workplace dietary interventions from the perspectives of key workplace management stakeholders, participating employees and researchers who were involved in intervention implementation.
3. Conduct a cost-analysis of specific workplace nutrition education, environmental dietary modification and combined (nutrition education and environmental dietary modification) interventions from an employer's perspective.
4. Conduct an economic evaluation of the complex workplace dietary interventions, whereby the costs and consequences of the workplace dietary interventions are evaluated and compared.

1.3. Research setting

The Food Choice at Work Study (FCW) was a non-randomised cluster controlled trial conducted in four large multi-national manufacturing workplaces based in Cork, Ireland. The workplaces manufactured products across different sectors including the food and beverage, health, automotive and information technology (IT) industries. The overall FCW was supported by the Health Research Board (HRB) Centre for Health and Diet Research grant (HRC2007/13) which was funded by the Irish Health Research Board and by the Department of Agriculture, Fisheries and Food. A student bursary was also awarded by the Irish Heart Foundation to a student involved in the FCW study. The candidate was supported by the HRB Scholar Programme in Health Services Research under grant (PHD/2007/16) and was also awarded a research bursary by the Nutrition and Health Foundation.

1.4. Description of the FCW Study

To provide context for this thesis, it is important to describe the data source. The data source for this thesis was the FCW study. A detailed description of the study design, trial profile, recruitment processes, intervention elements and methods of the FCW study has been published previously (13). These descriptions are also referenced frequently throughout this thesis. In summary, the cluster controlled trial was conducted in four large, similarly structured multi-national manufacturing workplaces based in Cork, Ireland. The interventions were implemented in the workplaces over a nine-month period. Data was collected at baseline (February – July 2013), at 3-4 months follow-up (September – October 2013) and at 7-9 months follow-up (January – March 2014).

1.4.1. Description of the FCW interventions

In the control workplace data was collected at baseline and at each stage of follow-up with participants informed that they were involved in a university-led study designed to observe employees' dietary behaviours. As this was the control workplace, nutrition education was not provided and no modifications were made to the environment. The only action to occur in this workplace was monitoring of employees through data collection (this is described in section 1.4.4.). A nutrition education intervention was provided in the second workplace, an environmental dietary modification intervention was implemented in the third workplace and the fourth workplace received a combined intervention (all elements of the nutrition education and environmental dietary modification interventions). As the purpose of this Chapter is to provide a summary of the thesis, a brief description of the intervention elements and the allocation of the interventions are provided on Table 1. However, a thorough description of the multicomponent interventions is presented in Table 2 which is presented in Chapter 2 of this thesis.

The intervention design was developed by the FCW research team and was informed by a detailed systematic review (8) and advice from catering stakeholders (Catering Managers Association of Ireland (CMAI)). The research team worked with the workplace stakeholders (human resources, occupational health managers and catering managers) to implement the specific interventions within the context of the individual workplaces. Each workplace had a research workplace leader who was based on-site and who collaborated with the workplace stakeholders to co-ordinate data collection and monitor adherence to the interventions.

Table 1: Summary of the FCW intervention elements

Workplace	Intervention implemented	Description of interventions
Control (Food & beverage industry)	Control	Monitored employees eating behaviours.
Education (Health industry)	Nutrition Education	This consisted of three elements; 1) monthly group presentations, 2) individual nutrition consultations and 3) detailed nutrition information, including the application of a healthy eating traffic light coding system to daily menus and vending machines. This displayed the number of calories and nutritional breakdown of the meal/food item.
Environment (Automotive industry)	Environmental dietary modification	This consisted of five elements; 1) restriction of fat, saturated fat, sugar and salt, 2) increase fibre, fruit and vegetables, 3) price discounts on whole fresh fruit, 4) strategic positioning of healthier alternatives and 5) portion size control.
Combined (IT industry)	Combined	This consisted of elements from both the nutrition education intervention and also the environmental dietary modification intervention.

1.4.2. Workplace recruitment

A comprehensive list of Cork based manufacturing companies was obtained from the Irish Industrial Development Authority (IDA) website (n = 107) and was systematically screened for eligibility over the phone in alphabetical order. From the overall list, the research team organised meetings with a total of 20 potentially suitable companies to discuss the feasibility of participating in the study. The four most suitable workplaces were then purposively selected and allocated to each intervention by the research team to ensure that all workplaces were able to comply with all of the intervention elements for the study duration. Workplaces were deemed eligible to participate if they employed >250 employees, were located in Cork, had a daily workplace canteen and were able to commit to the intervention for the duration of the study.

1.4.3. Employee recruitment

Employees were selected using random number generation software (Microsoft Excel) and were invited to participate if deemed eligible. Eligible employees were permanent, full-time employees who purchased and consumed at least one daily meal in their workplace. Employees were excluded if they did not work full-time, travelled regularly for work, were medically advised not to participate, were on long-term leave or were involved in an on-going diet programme external to their workplace. Further detail on workplace and employee recruitment has been published previously elsewhere (13).

1.4.4. Data collection

Data collection occurred at baseline and at each stage of follow-up (3-4 months and 7-9 months). Data were collected during employees working hours (excluding employees break times) within their work environments. Participants were asked to self-complete a number of questionnaires including; a socio-demographic and lifestyle questionnaire, a food frequency questionnaire (FFQ) and a nutrition knowledge questionnaire. All questionnaires had been previously validated for use in the Irish population (14). Participants in all four workplaces also underwent physical assessments (weight, body mass index (BMI), mid-way waist circumference and resting blood pressure) and 24-hour dietary recalls. These were conducted by trained research assistants/nutritionists as per the Standard Operating Procedures (SOP) manual for the FCW study (15). Detailed descriptions of data collection procedures have been published elsewhere (13).

1.4.5. Results of FCW Study

The main findings of the FCW study have been published and provide the strongest evidence to date with regards to the effects of high-intensity complex workplace dietary interventions (16). The comparative effectiveness of a workplace environmental dietary modification and an education intervention both alone and in combination was assessed, versus a control workplace. It was reported that there were significant positive changes in intakes of saturated fat (-0.7 g/day (SD 17.6)), salt (-1.3 g/day (95% CI: -2.3, -0.3)) and nutrition knowledge (+3.0 (SD 7.6)) between baseline data collection and 7-9 months follow-up between the combined intervention and the control. Furthermore, significant reductions in measured BMI (-1.2 kg/m2 (95% CI -2.385, -0.018)) were also observed in the combined intervention. Effects in the education intervention and environment intervention workplaces were smaller and generally non-significant. The findings demonstrate that a well-structured complex workplace dietary intervention, that combines nutrition education and environmental dietary modification reduces employees' dietary intakes of salt and saturated fat, improves their nutrition knowledge and decreases their BMI at 7-9 months follow-up. Therefore, combining such strategies may be an effective approach for promotion a healthy diet and weight loss at work.

1.5. Thesis outline

The FCW study was divided into three different work streams. The first work stream assessed the comparative effectiveness of the complex workplace dietary interventions on employees' dietary behaviours, nutrition knowledge and health status. The second work stream was focused on conducting a process evaluation to define the critical elements in the success or failure of the complex interventions. The third stream involved evaluating and comparing the costs and outcomes of the dietary interventions in the form of a cost-effectiveness analysis. The work presented in this thesis is focused specifically on both the second and the third work streams. Work stream one was the subject of a separate thesis. However, the candidate has been involved in the study design, data collection and publications for intervention related sub-studies that have emerged from work stream one. The context of this thesis within the overall FCW study is illustrated on Figure 1.

This thesis is comprised of four original research studies which address the aforementioned aim and objectives. These studies are also illustrated in Figure 1. The cross-sectional analysis presented in Chapter 3 was conducted to investigate the health status outcomes and lifestyle characteristics that influence the frequency of workplace absenteeism. Objective measures for both absenteeism and health status outcomes were included in an attempt to alleviate the uncertainty present in previous findings which relied heavily on self-reported measures for absenteeism and health status. There was some evidence to suggest that obesity, poor diet quality and low levels of physical activity negatively influenced workplace absenteeism. The study discusses how the implementation of evidence-based workplace health promotion initiatives, which are focused on improving modifiable health and lifestyle characteristics, may benefit employers in terms of lowering rates of absenteeism and employees in terms of improved health outcomes.

Chapter 4 presents the results of a detailed process evaluation which monitored and evaluated the implementation of the complex dietary interventions. The process evaluation consisted of semi-structured interviews with workplace stakeholders (managers and employees) and focus groups with researchers who were involved in the implementation of the interventions. The study outlines why rigorous process evaluation is required to understand why previous dietary interventions have had such limited effects and equivocal findings. The factors which facilitated or impeded the implementation process were identified and explored. It was revealed that consideration of contextual factors including workplace structures and cultures is integral for the successful implementation of workplace dietary interventions. Achieving cohesiveness between workplace stakeholders and the flexibility of key workplace stakeholders were identified as key facilitating factors.

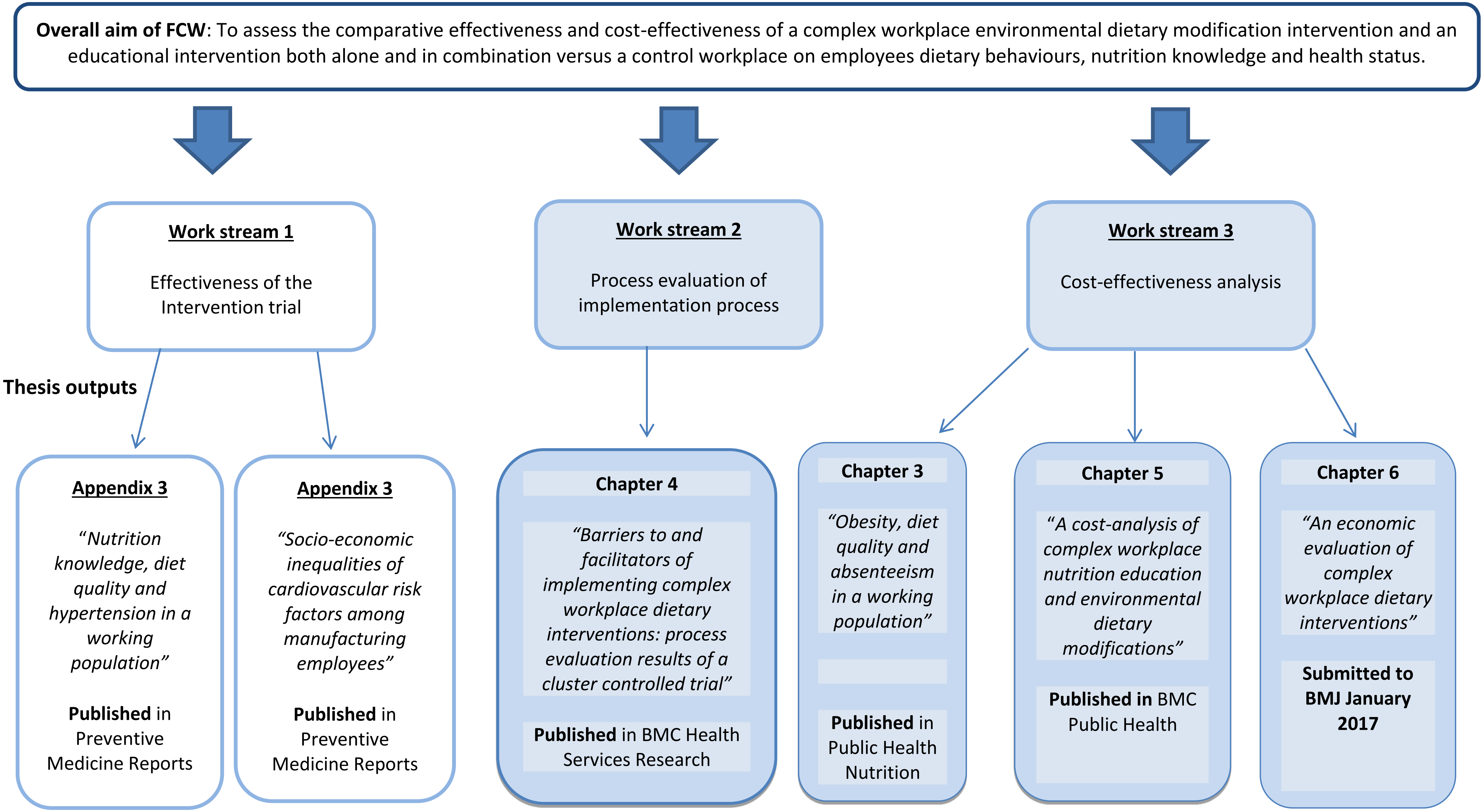
A cost-analysis of the workplace nutrition education, environmental dietary modification and combined (nutrition education and environmental dietary modification) interventions are presented in Chapter 5. A bottom-up approach using micro-costing was employed to estimate the costs associated with implementing and delivering the dietary interventions for a one-year period. Due to the dearth of evidence documented in the evidence to date regarding the financial impact of workplace dietary interventions, a detailed exposition of the costs associated with each intervention are presented. It was revealed that a workplace environmental dietary modification strategy added marginal additional cost relative to the control workplace.

Chapter 6 of this thesis outlines an economic evaluation where the costs and consequences of each dietary intervention were evaluated and compared. This involved: 1) a baseline cost-utility analysis (CUA) where quality-adjusted life-years (QALYs) were the outcome measure, 2) sensitivity analyses which consisted of cost-effectiveness analyses (CEA) of clinical measures (BMI, midway waist circumference and weight) and 3) a cost-benefit analysis which measured the cost-effectiveness of the dietary interventions when the monetary outcome was absenteeism. Effectiveness evidence from work stream one (clinical measures) and the costs that were identified in Chapter 5 informed this economic evaluation. A probabilistic sensitivity analysis, using a Monte

Carlo simulation was performed to assess parameter uncertainty. Incremental cost-effectiveness ratios (ICERs) were calculated for each intervention and are reported alongside calculations for Net Benefit. The economic evaluation demonstrated that workplace interventions that include environmental dietary modification elements may be a cost-effective way to improve the health of employees and to also produce potential cost-savings for employers. The economic evaluation also demonstrates the importance of considering the perspective taken by an economic evaluation when interpreting the results. The perspective taken will influence the values that are placed on the outcomes of the intervention which will then in turn influence the results and recommendations.

Finally, Chapter 7 summaries and integrates the findings from each of the four studies. This thesis provides critical evidence on the cost-effectiveness of complex workplace dietary interventions within a manufacturing working population. Findings will be used to inform employers, public health policy makers and national and international catering stakeholders on the cost-effectiveness of workplace dietary interventions. Results of the cross-sectional analysis of absenteeism will determine what health status outcomes and lifestyle characteristics influence the rate of absenteeism, thus highlighting potential target areas for future complex workplace interventions. In addition, the process evaluation can be used to guide the development of future complex dietary interventions, highlighting the critical factors to be considered during implementation of such interventions. Furthermore, it is envisaged that the findings will have a bearing on a broader level and will be used to compliment and extend the current translational research into using workplace dietary interventions as one potential way of reducing the prevalence and burden of diet-related diseases.

Figure 1: Outline of FCW study



2. BACKGROUND

2.1. Overview of background

This chapter presents an overview of the global burden of non-communicable diseases (NCDs) with a particular emphasis on obesity as a risk factor for developing chronic diseases. An outline of the current and the forecasted economic burden of obesity is also provided. Specifically, this chapter focuses on the interlinked challenges of obesity and workplace absenteeism. The escalating financial impact of workplace absenteeism at both a national and international level is also discussed. This chapter includes a discussion on the World Health Organisation's (WHO's) current global framework for reducing obesity and preventing diet-related diseases. This framework identifies the workplace as a priority setting for health promotion. The suitability of the workplace for implementing and delivering low-agency dietary interventions is also outlined in this chapter. Finally, this chapter considers the current limited evidence on the effectiveness and cost-effectiveness of workplace dietary interventions and how their processes have been poorly evaluated to date. A discussion on how these workplace interventions should be developed and evaluated within a complex intervention framework that is based on behavioural science theories is also included.

2.2. Defining NCDs

NCDs, also referred to as chronic diseases are not of a contagious origin and are therefore not transmitted from person to person (5). NCDs manifest from an array of complex multifaceted risk factors and typically consist of long latency periods, slow progression and extended durations of illness. It is important to note that there are three different levels of risk factors (17):

1. Primary causal factors (for example, smoking, dietary intakes of saturated fat, trans fat, sugar and salt, calorie excess, physical inactivity and gene markers).
2. Markers of underlying causal factors (for example, raised cholesterol levels and insulin resistance).
3. Early manifestations of the disease process (for example, hypertension) (17).

Although some of the outcomes of NCDs are treatable, a complete cure for many of the main NCDs (including cardiovascular diseases, stroke, some cancers and stroke) is yet to be discovered and they often give rise to the development of functional impairment or disability (18). NCDs are largely preventable and a number of common modifiable behavioural risk factors underlie their development. These risk factors can be reduced or controlled by an intervention, thus reducing the probability of a disease occurring (5, 18). The WHO has prioritised physical inactivity, tobacco and alcohol use and consumption of unhealthy diets (excess intakes of saturated fat and sodium and low intakes of fruit and vegetables) as the four main modifiable behavioural risk factors for developing NCDs. However, there is also consensus in international literature that the rising prevalence of obesity is one of the core drivers of the increase in NCDs globally (5, 19). The following sections of this chapter present the global population health and economic burden of NCDs with a particular emphasis on the impact of obesity.

2.3. Global burden of NCDs

The growing prevalence of NCDs remains a foremost global public health concern which continues to threaten both the social and economic development of low-, middle- and high-income countries (5). NCDs, specifically cardiovascular diseases, stroke, some types of cancers and diabetes have been identified as the leading cause of mortality in the world, imposing a considerable burden on human health (20). It is estimated that NCDs were responsible for 38 million deaths in 2012, which accounted for 67% of the total global deaths for that year (21). That is an increase from 36 million deaths (63% of total global deaths) in 2008 (22). Furthermore, due to a complex interaction between a number of factors including, an increasing global population, changing demographics, globalisation of unhealthy lifestyles and the increasing impact of NCDs, the current rising trajectory of NCD mortality is expected to persist with low- and middle-income countries likely to bear the largest proportion of the burden (23, 24). More than 16 million people worldwide die each year at a younger age (before the age of 70), with 86% of these premature deaths occurring in low- and middle-income countries (5, 23). It is estimated that the economic impact of these premature deaths will result in cumulative losses of US$7 trillion over the coming 15 years (5).

NCDs also have a detrimental effect on morbidity. In recent decades, improvements in healthcare and medical advancements have resulted in an increase in global life expectancy rates. However, as life expectancy rates increase, quality of life has been shown to be simultaneously decreasing as populations are living longer but are living with prolonged chronic conditions (21). Disability-adjusted life-years (DALYs) represent the sum of the years of life lost from premature death and years lived with disability and in 2010, it was estimated that 54% of the DALYs worldwide, were due to NCDs. This figure represented an increase of 10% from estimates of DALYs that were obtained in

1990 (21, 25). The WHO projects that if the rise in prevalence and significance of NCDs continues over the coming decades, not only will the proportion of DALYs attributable to NCDs substantially increase but it is also estimated that NCDs will account for more than 70% of all deaths by 2030 (21). Specifically, within an Irish context, recent research has revealed that despite improvements in overall mortality and life expectancy, the number of years living with disability (YLDs) has increased from 314 to 440 (per 100,000) between 1990 and 2010 (26).

2.3.1. NCDs and social inequalities

The NCD epidemic poses a compelling threat to global population health with the United Nations (UN) identifying the epidemic as one of the major challenges for achieving and maintaining sustainable human development in the 21st century (27-29). The challenges that are associated with NCDs can manifest in a number of ways. Firstly, NCDs can give rise to social inequalities across low-, middle- and high-income countries. Although it is often thought that the prevalence of NCDs increases concurrently with affluence in high-income countries however, this is only true for certain NCDs such as types of breast and colorectal cancers (30). As previously mentioned, a large proportion of global NCD deaths actually occur in low- and middle-income countries (22). This disproportionate burden between countries is owing to the concentration of major NCD risk factors in low- and middle-income countries (31). Individuals in these countries are exposed to risk factors such as high rates of both smoking and harmful alcohol consumption, high prevalence of hypertension and high prevalence of overweight and obesity (29, 30). In addition, these social inequalities in low- and middle-income countries are further exacerbated by a lack of resources to access NCD prevention or timely diagnosis and treatment of NCDs. In the majority of low-income countries, healthcare costs are paid directly by patients themselves, which creates further strain on already limited household resources and often results in individuals becoming trapped in poverty (23). NCDs also contribute substantially to inequalities within countries. A socio-economic gradient has been observed whereby individuals with low levels of income, low socio-economic status and those living in poorer communities have a higher risk of dying from NCDs than individuals with higher levels of income, higher socio-economic status and those who live in more advantaged communities (30).

2.3.2. Economic impact of NCDs

In addition to NCDs being one of the most common health problems worldwide, they are also one of the most costly and contribute substantially to perpetuating economic inequalities (32). The burden of NCDs extends beyond the threat to human morbidity and mortality and exerts considerable financial pressure not only on individual and household budgets but also on healthcare systems and governments worldwide (33). NCDs are chronic conditions that often require prolonged individual treatment and care and continued access to increasingly specialised healthcare services (24). This demand on healthcare can trap poor households in cycles of continued debt and illness and on a systems level the healthcare demand can jeopardise the sustainability of healthcare systems worldwide (32). The World Economic Forum identified chronic diseases as one of the largest threats to global economic growth and by using macroeconomic simulations, estimated that the cumulative lost output from NCDs over the next two decades will be in the region of US$47 trillion. For low- and middle-income countries alone, the economic costs are expected to reach US$21 trillion by 2030 (34). The World Health Economic Forum has also expressed concerns regarding the long-term macroeconomic impacts of NCDs on labour supply. NCD morbidity and mortality have also contributed to absenteeism and decreased productivity in the workplace which have in turn adversely affected the quality and quantity of the global labour force and human capital (34). It is forecasted that if the rise in prevalence and significance of NCDs continues to escalate, low-income countries will endure the heaviest economic burden. Furthermore it is estimated that a 10% rise in prevalence of NCDs results in a 0.5% decrease in annual economic growth (34, 35).

2.4. NCD risk factors

The main modifiable behavioural risk factors for NCDs have been extensively studied and are well documented in international literature (5, 32). These risk factors include: 1) tobacco use, 2) physical inactivity, 3) harmful consumption of alcohol and 4) poor dietary behaviours (consumption of foods that are high in saturated and trans fats, salt and added sugar and low consumption of fruit and vegetables). It is estimated that these four risk factors are responsible for more than two-thirds of all new NCDs cases and also increase the likelihood of complications occurring in people with NCDs (32, 36, 37). Evolving social and economic environments have resulted in these NCD risk factors becoming far-reaching across the globe (37). Consumption of foods high in saturated and trans fats, salt and sugar accounts for 40% of the global NCD mortality burden. This is followed by tobacco use which accounts for almost 17% and physical inactivity which accounts for 8% of all NCD deaths. Harmful alcohol consumption leads to 2.3 million deaths annually, of which 60% is due to NCDs (32).

2.5. Obesity as a risk factor for developing NCDs

While the aforementioned behavioural factors are recognised as the main NCD risk factors, it is important to acknowledge that one of the principal drivers of the increase in NCD prevalence is recognised as the increasing global prevalence of obesity (19). Obesity occurs when there is an imbalance between energy input and energy output and is defined through a measure of body mass index (BMI). BMI is a universal index recommended by the WHO for the classification of underweight, normal weight, overweight or obesity in adults. BMI is calculated by weight in kilograms divided by the square height in meters (kg/m^2). A BMI of ≤18.49 kg/m^2 is classified as underweight, normal weight is a BMI of 18.50-24.99kg/m^2, overweight is a BMI of 25.00-29.99kg/m^2 and obese is a of BMI ≥30.00kg/m^2 (38).

Although recognised as a disease in its own right, obesity has been identified as a direct underlying causal condition of NCDs and is associated with an increased risk of developing cardiovascular diseases, type 2 diabetes and certain types of cancers (39). The adverse health consequences are influenced by the extent of body weight, the location of body fat, the extent of weight gain during adulthood and an inactive lifestyle (38). Cardiovascular disease has been established as the most burdensome obesity-related disease and accounts for almost half of all global deaths attributable to NCDs each year (5). Furthermore approximately 5% of all deaths worldwide are attributable to obesity (19). This section of the thesis focuses specifically on obesity as a significant risk factor for chronic diseases. Obesity is described as a complex multi-faceted problem which stems from the interlinked issues of the increasingly sedentary nature of modern lifestyles, increased availability of and access to unhealthy food, calorie excess and overconsumption of food, individual psychological issues such as stress and genetic factors (19, 40).

2.5.1. Global burden of obesity

Obesity is one of the most preeminent public health issues in societies across the world and has the ability to adversely affect countries at every stage of development by jeopardising population health, burdening healthcare systems and creating tremendous economic costs (41, 42). The global prevalence of overweight and obesity has doubled since 1980 and the current global prevalence of obesity is now at a critical level with almost 30% of the global population (2.1 billion people) either overweight or obese (19, 42). Despite some countries reporting abatement in the rise of obesity prevalence since 2006, no significant reductions in obesity have been observed in any country between 2000 and 2013 (43). Moreover, an annual growth in prevalence of 0.5 to 1.5% of obesity is experienced in most countries and it is predicted that almost 50% of the global population will be overweight or obese by 2030 (19).

Based on current trajectories, research into forecasting projected obesity trends for the UK indicate that by 2035, 47% of men and 36% women will be obese. It is further estimated that by 2050 these obesity prevalence rates will rise to 60% for men and 50%

for women (44). The prevalence of overweight and obesity in Ireland are reflective of these current trends and projections. The 2008-2010 National Adults Nutrition Survey (NANS) estimated that 37% of Irish adults were overweight and 24% were obese (45). These estimates mirror the results from the Irish National Survey of Lifestyle, Attitudes and Nutrition in Ireland (SLÁN, 2007) which provided estimates of BMI based on self-reported height and weight. It was found that 36% of adults were overweight and 14% obese (14). A recent study which investigated the consequences of projected obesity trends in Ireland indicated that if current obesity trends persist, an estimated 85% of males and 85% of females will be either overweight or obese. Of these figures, 48% of males and 57% of females will be obese by 2030 (41).

2.5.2. Economic burden of obesity

Given the scale of the current obesity epidemic and the associated adverse health consequences, there has been an increasing global concern regarding the economic burden placed on societies in terms of direct and indirect costs. It has been reported that the global economic impact of obesity is approximately 2.8% of global GDP (US$2.0 trillion) which, to put into perspective is roughly equivalent to the global impact from smoking or from armed violence, war and terrorism (19). In high-income countries, obesity has been identified as one of the top three human generated economic burdens. In the UK alone, obesity generated an economic loss of more than US$70 billion in 2012 (3% of GDP for that year) (19). Similarly, obesity generated economic losses of US$663 billion (4.1% of GDP) in the US for the same year. Additionally, in high-income countries, between 2 and 7% of all healthcare spending is related to obesity. However, this estimate is likely to be modest as it does not include the cost of treating obesity-related diseases which when incorporated into estimates can account for up to 20% of healthcare budgets (19).

Within the Irish context, the economic burden of obesity is extensive and wider societal costs in terms of productivity loss and premature mortality have been measured. For the Republic of Ireland, in 2009, the direct and indirect costs of overweight and obesity were estimated at €1.13 billion. Of this figure, 35% represented direct healthcare costs (3). The main contributors to direct costs that were associated with obesity-related diseases included, the administration of drugs and hospital inpatient and day case care for cardiovascular disease and type 2 diabetes and GP care costs. The total direct healthcare cost for six major obesity-related conditions (cardiovascular disease, stroke, cancer, hypertension, type 2 diabetes and osteoarthritis) was estimated at €2.55 billion for the same year (3). When the indirect costs of obesity are considered, the financial toll of productivity loss is also considerable. It has been revealed that absenteeism and premature mortality caused primarily by cardiovascular diseases are the main causes of productivity loss. Together, overweight and obesity accounted for an estimated 2.7% of total annual health expenditure in the Republic of Ireland in 2009 (3).

2.5.3. Cost of obesity in the workplace

There is a growing body of evidence emerging which indicates that the obesity burden can constrain economic productivity and substantially increase costs for employers (46). Obesity and obesity-related diseases including cardiovascular diseases, stroke and diabetes have been linked to absenteeism and productivity loss in the workplace (4). In addition, obesity has also been identified as a significant predictor of both short-term and long-term sick leave (47, 48). When compared to non-obese employees, obese employees have an increased risk of and duration of sick leave, incurring greater productivity losses for employers (6, 47). Employees with high BMI measurements have been found to be less productive in the workplace due to a range of obesity-related conditions including arthritis, fatigue, breathlessness, poor concentration levels and depression. These obesity-related conditions are likely to lead to absenteeism due to the need to attend regular medical check-ups (19).

Research has indicated that absenteeism trends are congruent worldwide. In the US, while data on the total number of days lost to absenteeism is not available, it is estimated that employee absenteeism represents an average annual cost of US$789 per employee (49). In Ireland, the Irish Business and Employer's Confederation (IBEC) have reported that an estimated 11 million days are lost to absenteeism annually (50). These absenteeism rates have a substantial financial impact with absenteeism due to illness estimated to cost Irish businesses €1.5 billion each year, which equates to €818 per employee per year (51). These findings are mirrored in the UK, where workplace absenteeism is estimated to cost £29 billion annually with a reported 131 million days lost to absenteeism in 2013 alone (52).

While the indirect cost of absenteeism to employers consists primarily of losses incurred through reduced productivity (3), employers are also faced with the direct costs of absenteeism. These direct costs include employee sick pay schemes, medical referrals and the cost of replacing absent employees (51). When the direct and indirect costs of absenteeism are combined, employers are faced with unprecedented challenges as they attempt to cope with the crippling financial burden of absenteeism. This burden has stemmed from the increasing prevalence of obesity-related chronic diseases which are adversely affecting the health of their employees. In an effort to curtail the escalating costs associated with workplace absenteeism, some employers have begun investing in workplace health and well-being programmes (53).

A recent discussion paper published by the McKinsey Global Institute (MGI) outlines the need for sustainable obesity intervention strategies to be implemented at scale (19). The report focuses on the need to develop a holistic approach to combat obesity and details components of a potentially successful societal response to the obesity epidemic. As any single obesity prevention intervention is likely to have only a very small impact on an aggregated level, there is a need for the development and implementation of a comprehensive systemic program of multiple interventions (19, 54-56). The report assessed the cost-effectiveness of 74 different behavioural interventions which were in use or were being piloted across different environments, including schools, workplaces, healthcare settings and food service providers worldwide. The findings suggest that the delivery of a sustained societal approach to reversing obesity has the potential to be cost-effective from a societal perspective. It is estimated that the potential savings generated by reduced healthcare spending and improvements in productivity would outweigh the direct investment required to deliver the interventions, when assessed over the lifetime of a target population (19). For example, it was estimated that in the UK, the roll out of a comprehensive behavioural programme could halt the increasing prevalence of obesity which would result in an average saving of US$1.2 billion annually for the National Health Service (NHS) (19).

While it is imperative that investment into clinical and behavioural interventions to reduce obesity continues, it is also of critical importance that public health agenda progresses onwards with delivering as many behavioural interventions as possible in low risk environments such as workplaces or schools (19, 57). Evidence suggests that in order to be most effective, there is a need for these low risk interventions to be less reliant on approaches that elicit personal responsibility and focus more on environmental and societal modification elements that do not require an individual to make conscious choices (19, 58, 59). A relevant example of a low risk population based intervention includes recent population-wide efforts to reduce sodium intake as a strategy for preventing cardiovascular disease, which contributes the largest burden to NCD mortality. These interventions which included mandatory labelling of food packaging and reducing the salt content of processed foods have been shown to be highly cost-effective and in some instances resulted in a reduction of salt intake of between 5% to 30% (60). Environmental modification elements are designed to make the healthier choice the easier choice for individuals and include strategies such as: provision of healthy meals in school or work canteens, portion size restriction, removing unhealthy default options with meals, strategic rearrangement of food environments and increasing physical activity levels on school curricula. In such instances, there is a reduced need for individuals to make conscious decisions and less reliance on individual willpower (19, 58, 59). The following section of this chapter discusses the WHO's global action plan for the prevention and control of NCDs through the delivery of population level behavioural interventions. It also outlines how the workplace is an ideal low risk environment for implementing nutrition focused behavioural interventions.

2.6. Global framework for prevention and control of NCDs

As the magnitude of the global NCD crisis continues to accelerate, there is an urgent need to limit the known modifiable risk factors for NCDs (5, 23, 61). A global political framework which consists of members of the WHO and the UN organisations have in the past responded to the complex challenge presented by NCDs and have endorsed global strategies for the prevention and control of NCDs (38, 53, 62). However, these strategies have failed to make timely progress in easing the NCD burden. This failure motivated the WHO to translate the global strategies into palpable, achievable action plans and in order to strengthen international efforts, in May of 2013, the World Health Assembly endorsed the WHO's Global Action Plan for the Prevention and Control of NCDs 2013-2020 (5). The overall aim of the action plan is to reduce the avoidable NCD burden of morbidity, mortality and disability in order to improve quality of life and socioeconomic development worldwide (5). The action plan provides all member states with agendas and policy options for attaining a 25% reduction in premature mortality from NCDs by 2025.

One of the policy options for member states is concerned with promoting a healthy diet which specifically aims to “create health and nutrition-promotion environments, including through nutrition education, in schools, child care centres and other educational institutions, workplaces, clinics and hospitals and other private and public institutions” (5). Thus, the strategy recognises that the surrounding environment in which an individual lives and works has the potential to heavily influence their overall health status, including their dietary behaviours. Altering these environments in order to make the healthier choice the easier choice for individuals can serve as an important stimulus for dietary behaviour change. The next section of this chapter discusses how the workplace environment is now recognised as an ideal setting in which to implement behaviour change interventions that require individuals to use a low level of agency.

2.7. The workplace as a health promotion setting

The workplace has been identified as a priority setting for health promotion as it has the potential to directly influence the physical, mental, economic and social well-being of employees and ultimately the health and well-being of their families, communities and wider society as a whole (38, 63). As individuals are now spending increasingly longer hours (up to two-thirds of their waking hours) in their workplace environments, the workplace is recognised as an ideal setting in which to promote healthy dietary behaviours (2, 40) . Moreover, owing to the associated time constraints that can arise from longer working hours and also due to issues of convenience, individuals have become increasingly reliant on their workplaces to provide at least one of their daily meals (64, 65).

The workplace has been described as a 'microcosm' of society as it provides researchers with access to a relatively stable, controlled, homogenous population (66). It also allows for targeted health promotion programmes or initiatives to reach specific groups, who can sometimes be difficult to reach, for example adult men (67, 68). Furthermore, the workplace is conducive to facilitating the implementation of multi-component interventions as the workplace infrastructure can tolerate a range of different interacting components (69). The implementation of public health dietary interventions in the workplace is currently regarded as one of the best methods for evaluating the impact of environmental interventions on chronic diseases such as obesity (70). Evidence suggests that in order to improve employees dietary behaviours, the focus of dietary interventions needs to shift from individual nutrition education which require conscious decisions and concentrate on delivering environmental modification interventions that intervene at multiple levels of the workplace environment (12).

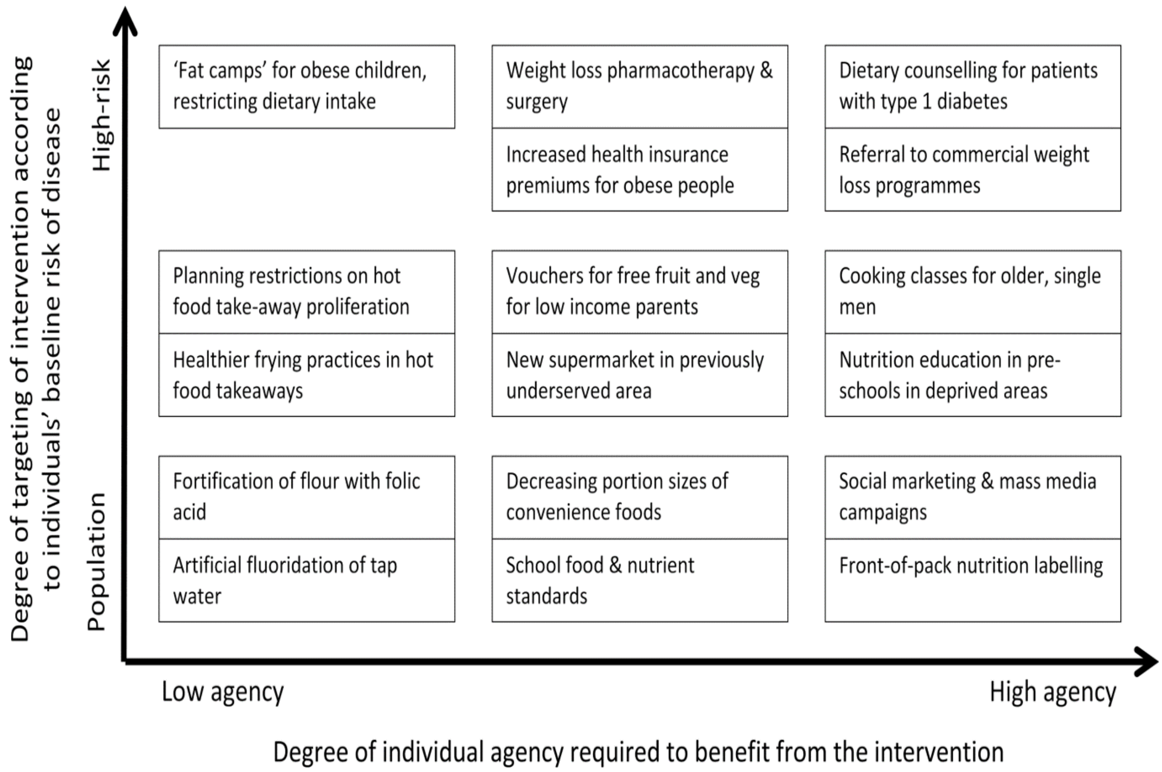
2.7.1. Workplace dietary interventions as a low agency population based approach

As outlined by Geoffrey Rose in his classic epidemiological paper 'sick individuals and sick populations', the priority of epidemiological research should be concerned with limiting the risk factors of a disease by discovering and controlling its causes (71). The fundamental principle of Rose's paper is that individual and population approaches to improving health differ profoundly and also achieve different aims. The individual 'high-risk' strategy is the traditional medical approach to disease prevention and is personal to both the individual and to the healthcare clinician (71, 72). A core aspect of the individual strategy is that it aims to identify and protect susceptible individuals from disease. The main advantages of this approach are that is gives rise to interventions that are specific to the individual patient and it offers a favourable ratio of benefits to risks. Nevertheless, the main disadvantages of this approach is that it does not attempt to identify and alter the underlying causes of a disease and is restricted to identifying only specific individuals who are susceptible to the particular disease. This approach is considered financially unfeasible as it would need to be sustained on a continuous basis (71).

In contrast, the population approach outlined by Rose attempts to alter the whole distribution of exposure within a population by removing the underlying causes that make a disease common (71). This approach contrasts to the individual approach as it involves interventions that are delivered across whole populations without prior identification of specific individuals who are at increased risk of the disease (57). The population approach is also considered behaviourally appropriate and seeks to alter society's norms of behaviour. A modern example of this would include the implementation of the smoking ban in Ireland in 2004 when Ireland became the first country in Europe to successfully ban tobacco smoking in all enclosed workplaces, including bars and restaurants (73). This ban has managed to change the norm of what is considered socially acceptable and Rose perceived this as one of the main advantages of this 'radical' population approach (71).

However, it is important to acknowledge that not all interventions that are developed based on a population health approach are the same. The level of individual agency required across interventions can vary considerably. Population interventions that are considered to be high-agency are typically focused on the provision of information or guidance and rely exclusively on an individual's ability to make and sustain behaviour change (74). Research indicates that low-agency population interventions are more likely to be successful in preventing and reducing the impact of NCDs when compared to high-agency interventions (57). It is suggested that interventions that require individuals to use little or no agency may be more effective as individuals are not required to consciously engage with any intervention or change their behaviour (for example reducing the portion size of food items in a workplace canteen). These types of interventions are also more recently referred to as 'nudge' interventions, which are discussed in further sections of this chapter within the context of behavioural science theory. Figure 2 illustrates a framework for describing a whole range of public health interventions using examples of diet and obesity prevention interventions (57). The framework depicts the degree of individual agency required to benefit from an intervention and ranges from low agency to high agency and the degree of targeting of interventions according to their risk of disease which ranges from population based to high risk individuals.

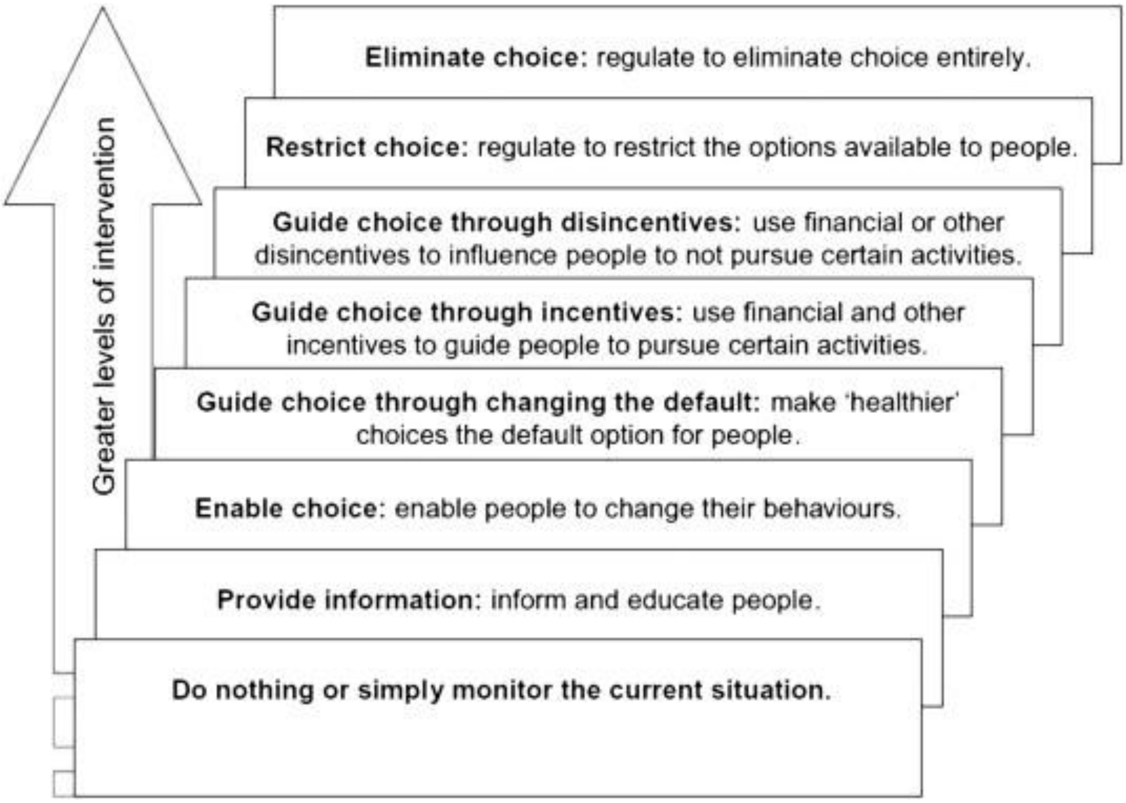
Figure 2: Framework for public health interventions



Source: Adapted from Adams et al (2016) (57).

When deciding on the level of agency that is appropriate for an intervention, it is also useful to consider the different ways that public health interventions or polices can affect people's choices. The Nuffield Council on Bioethics have developed an 'intervention ladder' which aims to provide a clear distinction between intervention options (75). It recognises that interventions which are higher up the ladder are more intrusive to individuals and therefore require stronger justification to implement (76). The ladder was developed with the intention of guiding policy makers as to when and how to intervene at a population level to improve health and wellbeing. It allows decision makers to estimate whether or not the benefits of the intervention will be sufficient enough to justify the intrusion in people's lives and also the financial cost of implementing the intervention (75, 76).

Figure 3: The Nuffield Council of Bioethics intervention ladder



Source: Nuffield Council of Bioethics: The Intervention Ladder (75).

The implementation of dietary interventions within the workplace can be considered to be a low-agency population approach to reducing the prevalence and impact of NCDs. Furthermore, according to the Nuffield Ladder of Interventions, such an approach would fall towards the middle/bottom of the ladder, indicating a lower level of intrusion on people's lives (Figure 3). This supports the recommendation of the McKinsey Report that states that the global public health agenda should be striving to implement as many low-risk population based interventions as possible with a view to easing the NCD burden (19). The current available evidence on the effectiveness of workplace dietary interventions is presented in the next section of this chapter.

2.7.2. Effectiveness of workplace dietary interventions

This section provides a brief overview of the currently limited available evidence regarding the effectiveness of workplace dietary interventions. A comprehensive systematic review which evaluated the effectiveness of workplace dietary modification interventions alone and in combination with nutrition education was conducted as part of the first work stream of the overall FCW study (8). The limited available evidence and the uncertainty surrounding the effectiveness of workplace dietary interventions was the motivation for the systematic review. The review concluded that limited evidence exists to suggest that workplace dietary modification interventions alone or in combination with nutrition education can result in small increases ($\geq$ half a portion per day) in fruit and vegetable consumption within workplaces. These findings somewhat mirror the findings from previous reviews that have reported that nutrition education and multi-component interventions have a moderate positive effect on dietary behaviour (7, 9, 12). However, as the review states, it is difficult to draw definite conclusions based on the findings due to the low-intensity design and poor methodological quality of the studies included in the review (7, 9, 12). Firstly, many of the studies neglected to include suitably matched control groups, secondly, many of the studies relied on self-reported measures for health and diet outcomes and thirdly the studies were poorly evaluated (8). This systematic review is currently the most recent review to be conducted in the area of evaluating the effectiveness of workplace dietary interventions alone and in combination with nutrition education.

The uncertainty regarding the effectiveness of workplace dietary interventions is further driven by the fact that previous workplace dietary interventions have been poorly evaluated with very few comprehensive process evaluations of workplace dietary interventions being conducted to date. The current available process evaluation evidence has focused mainly on the effectiveness of workplace dietary interventions rather than investigating why the interventions succeed or fail (77, 78). Thus, without rigorous evaluation of the implementation process, it will remain unclear why workplace dietary interventions are having such limited effects. In addition, a dearth of evidence also exists regarding the cost-effectiveness of workplace dietary interventions as many interventions have failed to report cost data alongside effectiveness data (12). There is a clear need for workplace dietary interventions of high-intensity to be developed and evaluated within a validated framework and to be reported in a standardised manner to enable the effectiveness and cost-effectiveness of such interventions to be compared. The next section of this chapter presents the application of a complex intervention framework within the context of behavioural science theory.

2.7.3. Effectiveness of workplace interventions and absenteeism

While the evidence-base is limited with regards to the impact of workplace dietary interventions on absenteeism, research which has focused on the effectiveness of workplace well-being interventions and workplace stress interventions on absenteeism is more readily available, although still somewhat scarce. A number of systematic reviews have been conducted in this area, however, their findings are limited due to methodological flaws in their study designs (i.e. absence of appropriate control workplaces). Nevertheless, the findings indicate that organisational-level interventions that include a participatory element for employees are associated with significant reductions in absenteeism (79-81). Specifically, workplace stress interventions that include participatory elements such as committees of employee representatives tasked with identifying workplace stressors and ways to reduce these stressors were more effective at reducing absenteeism when compared to interventions that included committees of management representatives (79). Research suggests that as employees' sense of autonomy with regards to their role in their workplace and their sense of control and involvement in decision-making within their workplace increase, the rate of absenteeism simultaneously decreases (81, 82).

Furthermore, a systematic review which focused on the effect of physical activity interventions within the workplace indicated that while comprehensive physical exercise programmes were not associated with a reduction in absenteeism, graded activity workplace interventions were associated with a significant reduction in workplace absenteeism (83). Graded activity involves the slow introduction of low levels of physical activity that are gradually increased on the basis of feedback from all workplace stakeholders (employers and employees). This further indicates that involving employees in decision-making regarding interventions within their workplace is associated with a reduction in absenteeism rates (83).

However, owing to consistent discrepancies in the literature in the way absenteeism data is recorded, it is difficult to draw definite conclusions with regards to the impact of workplace interventions on absenteeism rates (80, 83). The implementation of a standardised method for reporting sickness absence across workplaces would facilitate more robust investigations into the impact of interventions on workplace absences. However, despite the limited and somewhat ambiguous evidence, there is scope to improve employee absenteeism through the implementation of future workplace interventions that include elements designed to secure employee participation.

2.8. Complex intervention framework

Despite the poor quality of the limited available evidence on workplace dietary interventions, there is clear consensus in the literature that before these interventions can be implemented at scale, it is vital that high quality research is conducted (7-9, 12). Both the aforementioned McKinsey Report and the WHO's global action framework indicate that in order to be most effective, workplace dietary interventions which include both environmental and nutrition education strategies need to adhere to a complex intervention framework. This is to ensure that the interventions intervene at multiple levels of the workplace environment and consider all organisational levels (employees, workplace stakeholders and caterers) in their development, implementation and evaluation (5, 19). The importance of adhering to a complex intervention framework is also being driven by the need to further develop the evidence base on the effectiveness of public health interventions and by a growing understanding that evaluating interventions becomes more difficult when they increase in complexity.

A framework also enhances the evaluation of interventions and allows researchers to delve beyond knowing whether an intervention is effective or not, by revealing valuable information about when, why and how interventions are effective (10, 84). To enable workplace dietary interventions to be effective, it is evident that they should be developed within a complex intervention framework. This is owing to a number of different features of workplace dietary interventions, which include (10):

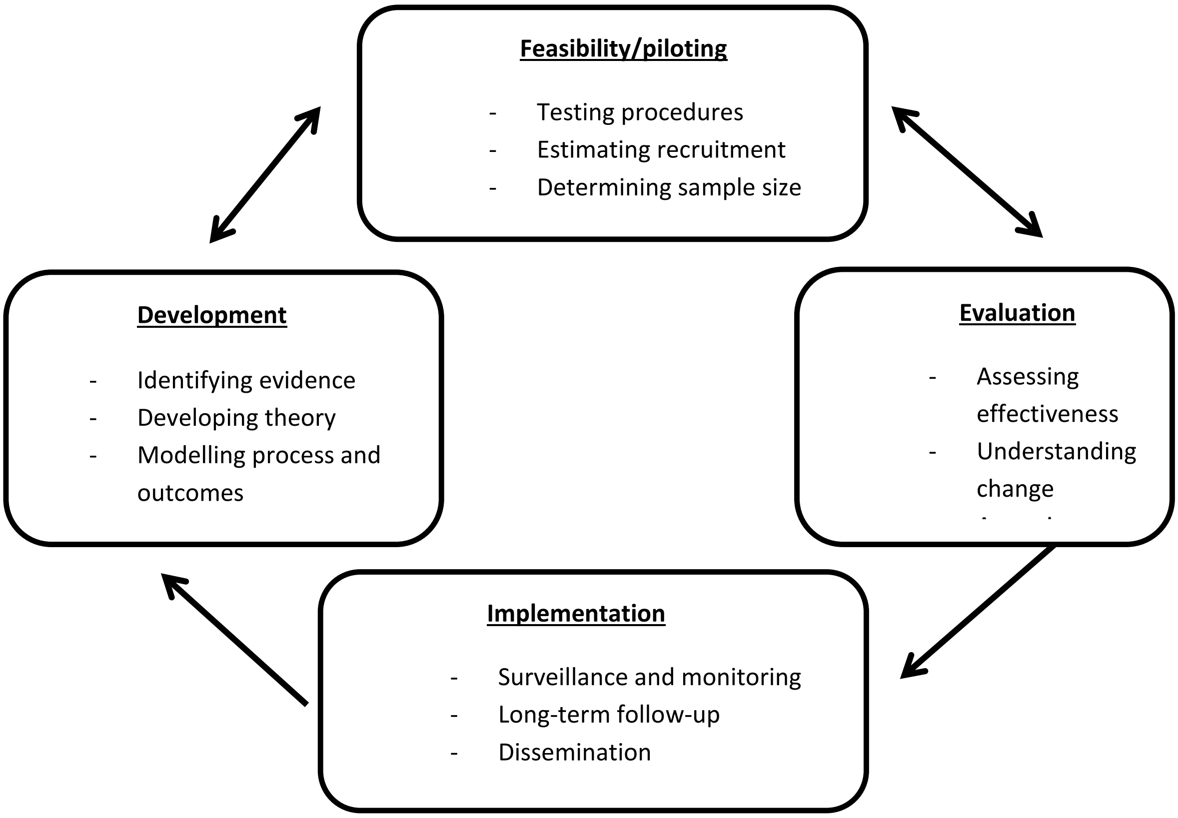
- The multicomponent design of interventions (interacting components of the nutrition education and environmental modification strategies).
- The different organisational levels that exist within workplaces including employees, different workplace stakeholders and caterers.
- The number of and variability of outcomes that are measured (clinical outcome measures, dietary behaviour, nutrition knowledge and cost outcomes).
- The presence of contextual factors (e.g. different work schedules or shift patterns) that might result in elements of the intervention being tailored to facilitate successful implementation and adherence to the intervention (10).

The Medical Research Council (MRC) has developed a complex intervention framework to provide guidance on the development, evaluation and implementation of complex interventions. The FCW study was developed according to this academically rigorous framework alongside the aforementioned systematic review (8, 10). The next section of this chapter presents the application of the MRC framework to complex workplace dietary interventions and discusses how these interventions might work.

2.9. Applying the MRC framework to complex workplace dietary interventions

The MRC framework advocates that workplace dietary interventions should be developed, implemented and evaluated within a complex framework (10). This framework was first published in 2000 and was subsequently revised and updated in 2008 to assist researchers in developing complex public health interventions. The framework consists of four main phases that include: 1) development, 2) feasibility and piloting, 3) evaluation and 4) implementation. These phases are illustrated on Figure 4. The MRC acknowledge that while it is helpful to think in terms of linear phases, in practice or 'real-life' settings, it may not always be possible to follow a cyclical sequence. Although reporting of the complex interventions is not included as one of the core phases of the framework, the MRC clearly specifies that evaluation of complex interventions should be reported in a standardised way using appropriate guidelines, for example the CONSORT guidelines for randomised controlled trials and the TREND guidelines for non-randomised controlled trials (10).

Figure 4: MRC framework for development and evaluation of complex interventions



Source: Developing and evaluating complex interventions: the new Medical Research Council guidance (10).

2.9.1. Development phase

The development of a complex intervention should adhere to the following three stages:

1. Identifying the existing evidence: Prior to an evaluation being undertaken, it is vital that an intervention is developed to the point where it can be expected to have a positive or worthwhile effect. This is established by identifying what is already known about similar interventions and the methods that have been used to evaluate them. If a recent high quality systematic review of the relevant evidence is not available, one should be conducted and updated when appropriate. In terms of the FCW study, a comprehensive systematic review of complex workplace dietary interventions was conducted under work stream one of the FCW (8).

2. Identifying and developing theory: Regardless of whether a researcher is developing the intervention or evaluating an existing intervention, it is important to develop a theoretical understanding of the likely process of change. There are two principal theoretical perspectives that can explain how complex workplace dietary interventions might work. These include the social ecological theory and the nudge theory and are outlined below:

Social ecological theory

Social ecological models recognise that individuals are embedded within larger social systems and attempt to demonstrate that contextual factors that can arise from interaction between an individual and their environment may influence health outcomes (85). It is suggested that public health and health promotion interventions are more likely to be effective if they adopt an ecological perspective. The theoretical underpinning of this perspective is that interventions should not only be targeted exclusively at individuals but should also be targeted at interpersonal, organisational and environmental level factors that can influence health behaviour (86, 87).

An example of an employee purchasing food during work hours can be used to demonstrate the ecological perspective that individuals and their environment are continually interacting and connecting on multiple levels (87). Employees have a choice to either bring their own food from home into the workplace or purchase food from their workplace canteen, shop or vending machines. A number of factors can influence the employee's food choice within their workplace including personal preferences, dietary habits, availability of food, cost and time constraints etc. Thus, it is indicated that food choice is complex and is influenced by a range of multiple factors (individual, organisational, community or cultural) at multiple different (micro, meso and macro) societal levels (69, 86). It is evident that the theoretical foundation of how workplace dietary interventions might work is based on social ecological theory. Employees' dietary behaviour is influenced by the context and structure of their workplace environment and a workplace that promotes healthy dietary behaviours may enable employees to choose healthier food options within their workplaces (69, 86).

Nudge theory

Choice architecture, which is also referred to as 'nudging' involves purposively modifying an environment to change individuals' health behaviours. Nudging builds upon psychological and sociological theories that demonstrate how surrounding environments can influence and constrain human behaviour (88). Nudging has its foundations in behavioural economics and social psychology and attempts to explain why people behave in ways that deviate from what is deemed rational which is defined in classical economics (88). In recent times, it has become increasingly recognised among policy makers as a potentially valuable method for influencing health behaviours at a population level (89).

Nudge interventions which utilise choice architecture can be classified as low agency population interventions and involves changes to the placement or properties of objects at the micro-environmental level (i.e. buildings such as restaurants, workplaces or schools) (57). Examples of choice architecture include reducing the portion size or availability of unhealthy foods within a workplace canteen. These modifications require minimal conscious engagement by employees and are usually conducted via unconscious psychological processes. Within the context of the FCW study, which this thesis is evaluating, the complex interventions were guided by a soft paternalistic ‘nudge’ theoretical perspective. Table 2 includes a detailed description of the multicomponent FCW interventions.

Table 2: Description of the FCW interventions

Intervention	Description of elements
Nutrition education	*Group presentations:* Monthly nutrition sessions (30 minutes per session) were delivered in the workplace by the FCW nutritionist during employees' break times. Topics included portion control, food labelling and general healthy eating guidelines. Sessions were repeated to ensure they were accessible to employees on different shift cycles.
	Individual nutrition consultations: Participants received one-to-one dietary counselling with the FCW nutritionist. Consultations were tailored for each participant based on their lifestyle, physical assessment results and dietary recall assessments. The nutritionist provided advice on how to follow a healthy diet, reach or maintain a healthy body weight and achieve healthy resting blood pressure. Participants also received a healthy eating booklet and a personalised measurement card.
	Detailed nutrition information: Detailed nutrition information was prepared by the FCW nutritionist and displayed in the workplace throughout the intervention time period. The information included posters, leaflets, emails and daily calorie menu labelling with a unique traffic-light coding system. A healthy eating chat table was also provided twice a month during break times to provide employees with an opportunity to ask the nutritionist about healthy eating.
	Menu modifications: Saturated fat, sugar and salt were restricted. Stock and bouillon were replaced with low-salt stock options. Salt was replaced with fresh herbs, spices and garlic for additional flavour. High salt savoury options, high-salt products and processed meats were reduced and replaced where possible with low-salt options. Full-fat

	dairy products were replaced with low-fat options where possible. Cream and cheese were not used as a garnish on meals and the amount of cheddar in all meals was reduced. Cooking methods using oil (deep-fat frying) were limited and replaced with boiling, poaching, grilling, baking and steaming where possible. Plant oils were introduced for cooking. Sauces and accompaniments were not added to any meal unless they were specifically requested by the employee. Chips and French fries were removed from the menus two days a week and were replaced with different potato options such as baked potatoes. Soft carbonated drinks were restricted and replaced with water, milk and unsweetened options.
	Increase in fibre and availability of fruit and vegetables: White pasta, rice and bread were replaced with wholegrain alternatives. Fruit and vegetables were added to rice, pasta, soup and meat dishes. Fresh whole fruit was made available throughout the day and a buffet-style fresh salad bar was available to accompany any dish on a daily basis.
Environmental dietary modification	*Price discounts:* Portions of whole fresh fruit were offered at discount prices on a daily basis.
	Strategic positioning of food: Healthier alternatives were strategically positioned throughout the workplace canteen. Healthy snacks, such as fresh fruit, dried nuts, seeds, brown sandwiches and brown soda bread were positioned at eye level at the entrance of the canteen and in the vending machines. Free-flowing salt and sugar were removed from tables and replaced with sachets.
	Portion size control: Standard serving tools were used to control portion size at mealtimes. Catering staff received training from the FCW nutritionist regarding strict portion size control.

The aim of the FCW study was to assess the comparative effectiveness of nutrition education versus a control workplace, environmental education versus a control workplace and a combined intervention (which included elements from both nutrition education and environmental modification) versus a control workplace. The nutrition education intervention was designed to create positive reinforcement with indirect suggestions for healthy food choices in an effort to improve the dietary behaviour of employees. Elements such as the one-to-one nutrition consultations and calorie and traffic light menu labelling were designed to prompt both conscious (repositioning of healthier alternatives) and unconscious (menu modification) thoughts.

3. Modelling process and outcomes: The advantage of modelling a complex intervention prior to full scale evaluation is that it can provide useful information regarding potential weakness in the design of the intervention. In addition, modelling prior to evaluation may also reveal that a full scale evaluation is unnecessary (10).

2.9.2. Feasibility phase

The challenges posed by acceptability, compliance, intervention delivery, recruitment, attrition and small effect sizes often weaken the evaluations of complex interventions (10). Thus, a feasibility study is of critical importance in order to appreciate any potential uncertainties and to also anticipate context specific challenges in the environment where the intervention will be implemented, for example, the logistics of work schedules in manufacturing workplaces.

2.9.3. Evaluation phase

When evaluating complex public health interventions, depending on research questions and circumstances, there are many different study designs to choose from. As many behaviour interventions consist of multiple interacting components, the effects of these interventions are best tested using a randomised controlled trial (RCT) (10, 70). Randomisation offers the most robust method of preventing selection bias of participants and the MRC advocate that it should always be considered first when evaluating interventions (10). RCTs are regarded as the gold standard for establishing the effectiveness of interventions, in situations when randomisation is feasible. There is an increasing demand within research to develop workplace dietary interventions within a complex intervention framework. However, difficulty lies in applying evaluation methods that can achieve the same level of rigour that the RCT design within the context of real-world settings (i.e. workplaces) (9, 10). It is therefore imperative that multi-level workplace interventions consider the intensity level of the intervention that is being delivered, specific workplace structures and the needs of workplace stakeholders and employees.

Understanding the process of change

The MRC have identified process evaluation as an essential part of designing and testing complex interventions (90). Process evaluations explore the manner in which an intervention is implemented and can offer invaluable insight into how and why an intervention succeeded or failed. A process evaluation that is conducted concurrently with a trial can effectively monitor and evaluate compliance to and fidelity of interventions and identify contextual factors that may be associated with a variation in outcomes (91, 92). Evaluating the process of implementation is of particular importance in behaviour change interventions. Obesity and other NCD's have been referred to as a 'wicked problem' in public health. Wicked public health problems are defined as issues that are continually evolving, have many causal levels and have no single solution that applies in all circumstances (2). Thus, comprehensive process evaluations of behavioural interventions designed to reduce obesity offer a means of developing a transparent assessment of the implementation stage. Chapter 4 of this thesis presents the results of a detailed process evaluation which monitored and evaluated the implementation of the FCW complex dietary interventions.

Assessing cost-effectiveness

The MRC framework supports the consensus from the evidence base that an economic evaluation should also be completed when testing a complex intervention (10). If an intervention is proven to be effective at improving health behaviours of employees, it is more likely that the intervention will be implemented at scale if the outcomes are presented in a way that is of relevance (cost outcomes) to those who are bearing the costs of the intervention (employers and policy makers) (10). Chapter 5 of this thesis provides a detailed exposition of the costs associated with implementing and delivering the FCW complex workplace dietary interventions and Chapter 6 outlines an economic evaluation where the costs and consequences of each of the interventions were evaluated and compared.

2.9.4. Implementation stage

A key element of the implementation stage of the MRC framework is concerned with the dissemination of results. Results should be disseminated as widely and as persuasively as possible, particularly in peer-reviewed academic journals (10, 93). Nevertheless, it is important the results are presented in a tangible manner so they are meaningful and accessible to decision makers and policy makers. While long-term follow-up of complex interventions are uncommon, such practices would yield highly informative and useful results. The MRC framework suggests that consideration for collecting long-term data should be built into the design of the study at the outset (10).

2.10. Background summary

NCDs pose a considerable threat to human sustainability and account for the largest proportion of morbidity and mortality worldwide. NCDs are largely preventable, however as a result of changing environments and the globalisation of unhealthy lifestyles, the prevalence of NCDs and the associated human and economic burdens are increasing. Specifically, obesity has been identified as a condition which drives both the prevalence and impact of NCDs.

Obesity has been identified as both a short and long term predictor of absenteeism in the workplace. The direct and indirect costs of workplace are creating a crippling financial burden for employers and in an attempt to curtail the escalating costs many employers have begun implementing workplace interventions. The workplace has been recognised by the WHO as a priority environment for the promotion of healthy dietary behaviours. This is owing to the fact that most adults are now spending up to two-thirds of their waking hours in their work environment. However, evidence is limited regarding the effectiveness of workplace dietary interventions. Interventions to date have been of low-intensity, poor methodological quality and poorly evaluated. There is an urgent need to develop workplace dietary interventions within a complex intervention framework that includes evaluation of process alongside evaluation of effectiveness and cost-effectiveness.

In this thesis, the candidate used data obtained from the FCW study which assessed the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention of high intensity both alone and in combination versus a control workplace. Firstly, using objective measures for absenteeism and health status, an investigation of what health status outcomes and lifestyle factors influence workplace absenteeism will be discussed. Secondly, a comprehensive process evaluation which examined the barriers to and facilitators of implementing complex workplace interventions from the perspective of key workplace stakeholders and researchers involved in implementation is discussed. Thirdly, a detailed exposition of the costs associated with implementing and delivering a complex workplace dietary intervention is presented. Finally, an economic evaluation which involved conducting; 1) a baseline CUA to measure the cost-effectiveness of the interventions in terms of QALYs, 2) sensitivity analyses to test the robustness of the QALYs which involved performing CEAs using clinical outcome measures (BMI, midway waist circumference and weight) and 3) a CBA which placed a monetary value on absenteeism is discussed.

3. OBESITY, DIET QUALITY AND ABSENTEEISM IN A WORKING POPULATION

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ANN KIRBY

AILEEN MURPHY

FIONA GEANEY

THIS PAPER WAS PUBLISHED IN PUBLIC HEALTH NUTRITION (SEE APPENDIX 4)

3.1. Abstract

Objective: The relationship between workplace absenteeism and adverse lifestyle factors (smoking, physical inactivity and poor dietary patterns) remains ambiguous. Reliance on self-reported absenteeism and obesity measures may contribute to this uncertainty. Using objective absenteeism and health status measures, this study aims to investigate what health status outcomes and lifestyle factors influence workplace absenteeism.

Design: Cross-sectional data were obtained from a complex workplace dietary intervention trial, the Food Choice at Work Study.

Setting: Four multinational manufacturing workplaces in Cork, Ireland.

Subjects: Participants included 540 randomly selected employees from the four workplaces. Annual count absenteeism data were collected. Physical assessments included objective health status measures (body mass index, midway waist circumference and blood pressure). Food Frequency Questionnaires measured diet quality from which DASH (Dietary Approaches to Stop Hypertension) scores were constructed. A zero-inflated negative binomial (zinb) regression model examined associations between health status outcomes, lifestyle characteristics and absenteeism.

Results: The mean number of absences was 2.5 days (standard deviation: 4.5 days). After controlling for socio-demographic and lifestyle characteristics, the zinb model indicated that central obesity was positively associated with absenteeism, increasing expected absence rate by 72%. Consuming a high quality diet and engaging in moderate levels of physical activity were negatively associated with absenteeism and reduced expected frequency by 50% and 36% respectively. Being in a managerial/supervisory position also reduced expected frequency by 50%.

Conclusions: To reduce absenteeism, workplace health promotion policies should incorporate recommendations designed to prevent and manage excess weight, improve diet quality and increase physical activity levels of employees.

3.2. Introduction

The growing prevalence and associated burden of chronic diet related diseases is endangering population health and the sustainability of healthcare systems worldwide (2, 38). Obesity and obesity-related diseases including cardiovascular disease, stroke and diabetes have been linked to absenteeism and productivity loss in the workplace, generating substantial costs for societies and employers (4). In 2011 it was reported that absenteeism due to illness was costing Irish businesses €1.5 billion a year (€818 per employee per year) (51). Furthermore, productivity loss due to overweight and obesity was estimated at €865 million in 2009 in Ireland, with absenteeism identified as the main driver (3). In an effort to curtail this cost escalation, workplace health promotion has moved to the forefront of organisational agendas. However, it is imperative that workplace health promotion guidelines and polices are developed and informed by objective research (53).

The workplace has been identified as a priority setting for health promotion as it can facilitate the delivery of health promotion initiatives by providing necessary infrastructure and a stable population in a controlled environment (2, 38, 40, 67). Given that employees are spending longer periods of time in their work environments, the workplace has the capacity to influence the physical, mental, economic and social wellbeing of employees and consequently the health and well-being of their families and communities (53, 67). It is widely accepted that health promotion should form a fundamental element of workplace culture as the future success of organisations in a progressively globalised marketplace is dependent on establishing a balance between organisational targets and employees' health (67).

In terms of health status outcomes, much research into the determinants of workplace absenteeism has focused on obesity. The most recent available data for Ireland suggests that overweight and obesity rates may have reached a plateau in Irish adults but at a high level with 61% of adults being classified as overweight (37%) and obese (24%) (94). Obesity has been identified as a significant predictor of sick leave and studies indicate that a gradient exists between obesity and absenteeism (46, 48, 95-98). This gradient may be attributable to the adverse health implications associated with obesity, which increase the likelihood of absences occurring (4, 97). There is consensus in the evidence-base regarding the relationship between obesity and absenteeism, however a limitation of the evidence is the wide use of self-reported measures for absenteeism and obesity (46, 98). Moreover, recent evidence suggests that general obesity measures such as body mass index (BMI) can lead to misclassification of body fat (98, 99). Central obesity is a strong indicator of chronic diet related diseases and thus, a potential predictor of sick leave (98, 99). However, further research is warranted as few studies have included both measures of central obesity and BMI (98).

The causes of workplace absenteeism are multifaceted and are not limited to obesity and health status outcomes. Absenteeism may be attributable to many different factors, including lifestyle factors, demographic and socio-economic characteristics. The relationship between absenteeism and modifiable lifestyle characteristics remains ambiguous. For example, both positive (97, 100) and negative (96) associations between physical activity and absenteeism have been reported. Similarly, inconsistent findings have been reported regarding smoking status and absenteeism (96, 97, 101, 102). This uncertainty may be due to different outcome measurements being used and issues including type of work and working conditions (97, 103). In addition, inconclusive findings have been reported with respect to the relationship between absenteeism and alcohol consumption (104, 105). In relation to diet quality, there is a paucity of evidence investigating the impact of dietary behaviours on absenteeism (106). One of the few studies conducted, reported that improvements in dietary behaviours such as reducing consumption of fatty foods and increasing fruit and vegetable intake significantly improved presenteeism of employees (107). Owing to the aetiological role of the diet in the causation and prevention of chronic diet related diseases, it is vital that the impact of dietary behaviour on absenteeism is robustly examined (108). With regards to demographic and socio-economic characteristics, studies have reported a clear negative linear association between socio-economic status and absenteeism (109). Higher education level and increased job responsibility are associated with lower rates of absenteeism (110, 111).

This aim of this study is to investigate what health status outcomes and lifestyle characteristics influence the frequency of workplace absenteeism, using objective measures for both absenteeism and health status outcomes. Findings will inform both employers and public health policy makers on what guidelines should be included in workplace health promotion policies in an effort to improve employee health and potentially reduce absenteeism.

3.3. Methods

3.3.1. Data source

Data for the present study were obtained from a large clustered controlled trial, the Food Choice at Work Study (FCW). Full details of the FCW study's protocol is published elsewhere (13). The FCW study assessed the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention of high intensity both alone and in combination versus a control workplace. The present study is a cross-sectional analysis of baseline data collected prior to the implementation of the FCW interventions. The FCW study had a sample size of 828 employees (aged 18-64 years). Employees were recruited from the four workplaces (workplace A: 100 (70% response rate), workplace B: 224 (70% response rate), workplace C: 392 (60% response rate), workplace D: 112 (91% response rate)). The number of employees recruited per workplace reflected the difference in company size (13). Eligible employees were permanent, full-time employees who purchased and consumed at least one daily meal in work. Employees who were medically advised not to participate and those that were involved in an on-going diet programme external to work were excluded from the study. Throughout the FCW study, participants underwent physical assessments (height, weight, midway waist circumference and blood pressure) that were conducted by trained research assistants (15). Demographic, nutrition knowledge and food frequency questionnaires were self-completed by participants. Participants provided written informed consent to enable their workplaces to make their absence history available to the research team. A total of 540 employees consented, giving a response rate of 65% for the present study.

3.3.2. Absenteeism

Annual count absenteeism data for each participant was obtained from the Human Resources Department of each workplace. Frequency of absences was recorded in working days, based on an eight-hour working day (forty-hour working week). As this is a baseline cross-sectional analysis, absenteeism data were collected for a time period prior to the implementation of the FCW study interventions (July 2012 to July 2013). Maternity or paternity leave absences were excluded from the analysis. The total number of days absent during this time period was specified as the dependent integer count variable for analysis.

3.3.3. Health status and lifestyle characteristics

Exposure data were collected at the baseline stage of data collection, prior to the implementation of the FCW study interventions (February – July 2013). Measured BMI was calculated as kg/m^2 in order to classify participants as underweight (BMI $\leq$ 18.49 kg/m^2), normal weight (BMI = 18.50 – 24.99 kg/m^2), overweight (BMI = 25.00 – 29.99 kg/m^2) or obese (BMI $\geq$ 30.00 kg/m^2) (38). As BMI is a weight-for-height measure and is unable to distinguish between body fat and lean mass, midway waist circumference measurements (central obesity) were also included as an obesity indicator. Participants were classified as centrally obese if their midway waist circumference was measured at

≥ 94 cm for males and ≥ 80 cm for females (112). Participants' resting blood pressure was measured and participants were recorded as hypertensive if their average systolic reading was ≥ 140 mm Hg or average diastolic was ≥ 90 mm Hg (113).

An International Physical Activity Questionnaire (IPAQ) score was calculated for physical activity levels (14). These scores were classified as low (<5,000 steps/day), moderate (5,000-10,000 steps/day) and high (>10,000 steps/day) levels of physical activity. Smoking status was recoded into three categories; 'non-smokers' (participants who had never smoked more than 100 cigarettes), 'former smokers' (participants who had smoked at least 100 cigarettes but do not smoke at present) and 'current smokers' (participants smoking at present) (14). Alcohol consumption was estimated using the units of alcohol consumed per week.

Diet quality was assessed using Food Frequency Questionnaires (FFQ), which measured the average frequency of consumption of food from nine food groups: wholegrains, fruit, vegetables, legumes, low-fat dairy, red processed meat, sweetened snacks and beverages, salty snacks and sodium (114). A DASH (Dietary Approaches to Stop Hypertension) score was constructed from the FFQ, with a high DASH score indicating high diet quality (115). The DASH diet pattern promotes low intakes of fat, sodium and processed foods and high intakes of fruit and vegetables (115). This diet pattern has been found to lower blood pressure and cholesterol and is promoted internationally. To further assess sodium intake, spot urine samples were obtained to analyse sodium excretion. Each participant provided one early morning sample and one evening sample which were taken 12 hours apart. Daily average salt intakes were estimated based on the average between both samples. These estimates were compared to the upper tolerable limit of 6g per day for Irish populations as set out in national guidelines (116).

Participants' nutrition knowledge was assessed using the validated general nutrition knowledge questionnaire which included four sections 1) advice from health experts, 2) food groups and food sources, 3) food choice and 4) diet-disease relationships. Nine questions were modified to include recent evidence in nutrition knowledge (e.g. what health problems are related to excess sugar?). Food items were changed to increase participants' understanding (e.g. orange juice instead of orange squash). An overall score was constructed and further categorised into high or low nutrition knowledge score (117). Socio-demographic and lifestyle characteristics (gender, age, ethnicity, marital status, education level, job position, smoking and physical activity level) were self-reported using a demographic questionnaire (14). The highest level of completed education and job type served as indicators of socio-economic status. Education was transformed into a four level variable: none/primary level only, secondary level only, diploma/certificate and degree/postgraduate level. Job type was also transformed into a four level variable: human resources (HR)/finance/administration, information technology (IT)/engineering, production and maintenance/sanitation/catering. Job position was a measure of job responsibility and employees were classified as being in either a managerial/supervisory position or a non-managerial/non-supervisory position.

3.3.4. Statistical analysis

All analyses were carried out using STATA version 12 (StataCorp, College Station, TX, US). Descriptive statistics were performed to generate a demographic profile of the study populations' baseline characteristics. As the annual number of days absent from work is a non-negative integer number, we employed a count data model to examine what health status outcomes and lifestyle factors influence the frequency of days absent from work. Previous studies have carried out multivariate analyses of count data models (Poisson, negative binomial and zero-inflated models) to establish what factors are associated with workplace absenteeism (118, 119). Typically, the Poisson model is the initial model considered when analysing count variables. Central to the Poisson model is the assumption that the conditional mean of the outcome is equal to the conditional variance. However, as is often the case, the conditional variance exceeds the mean, which results in overdispersion. In order to overcome the issue of overdispersion, negative binomial models can be used (120). A zero inflated negative binomial (zinb) model is employed when count variables have excessive zeros and are overdispersed. Moreover, a zinb model allows for excess zeros to be modelled independently (121). In order to assess whether or not the zinb model was appropriate for our data, we applied a likelihood ratio test for *alpha=0*, the significance of which ($p = 0.0001$) indicated the presence of overdispersion and preference for a zinb over a zero-inflated Poisson model (zip). We also applied the *vuong* non-nested model test statistic which compared the zinb to a negative binomial regression model and a significant z-test score ($z = 2.59$, $p > z = 0.0048$) indicated that the zinb was the best fit. Thus, a zinb was considered the most appropriate model due to overdispersion and the excessive frequency of zeros. We controlled for potential confounders including health (hypertension), lifestyle (smoking, alcohol consumption and nutrition knowledge) and socio-demographic (age, gender, education status and marital status)) characteristics. Incident rate ratios (IRRs) were calculated for the zinb regression model and in an effort to control for heterogeneity, robust standard errors were calculated.

3.4. Results

With regards to absenteeism, 44% of the study population (n=237) were absent at some stage during the specified period (July 2012 – July 2013), with 14% of employees absent for 1-2 days and 30% of employees absent for 3 or more days. The mean number of absent days was 2.5 days with a standard deviation of 4.5 days. Baseline socio-demographic, lifestyle and physical characteristics for the study population are summarised in Table 3. The mean numbers of predicted days absent across different groups are also included in Table 3. The highest proportion of participants were male (67%), aged between 30-44 years (62%), married /cohabiting (69%) and were white Irish (90%). A total of 42% of the population had a tertiary education (degree or postgraduate degree level). Over 22% of the population were in a HR, finance or administrative position, 28% held an IT or engineering position and over 38% of the population worked in production. A total of 20% of the population were in a managerial or supervisory position. A total of 18% of the population were current smokers and 43% reported having low levels of physical activity. A higher proportion of males (14%) reported consuming at least 14 units of alcohol per week compared to females (3%). Half of the participants were overweight (48%) and centrally obese (51%). According to urinary sodium analyses, a total of 38.7% of the population exceeded the tolerable upper limit of 6g of salt per day. Over 60% of participants had a low quality diet and 84.1% had low levels of nutrition knowledge.

Table 3: Socio-demographic, health and lifestyle characteristics of study population

	Men n = 359 (66.5%)	Women n = 181 (33.5%)	Total (n = 540)	Mean no. predicted days absent
Socio-demographic characteristics				
Age group (years)				
18-29	37 (10.3)	25 (13.8)	62 (11.5)	2.8
30-44	226 (63.0)	106 (58.6)	332 (61.5)	2.7
45-65	96 (26.7)	50 (27.6)	146 (27.0)	2.1
Ethnicity				
White Irish	327 (91.1)	159 (87.8)	486 (90.0)	2.2
Other[a]	32 (8.9)	22 (12.2)	54 (10.0)	2.6
Educational level				
None/primary level	5 (1.4)	1 (0.6)	6 (1.1)	2.8
Secondary level	86 (24.0)	76 (42.0)	162 (30.0)	2.7
Diploma/certificate	92 (25.6)	52 (28.7)	144 (26.7)	2.8
Degree/postgrad level	176 (49.0)	52 (28.7)	228 (42.2)	2.2
Marital status				
Married/cohabiting	267 (74.4)	104 (57.5)	371 (68.7)	2.5
Separated/divorced/widowed	14 (3.9)	13 (7.2)	27 (5)	2.2
Single/never married	78 (21.7)	64 (35.3)	142 (26.3)	2.7
Job type				
HR/finance/admin	64 (17.8)	57 (31.5)	121 (22.4)	2.4
IT/engineering	137 (38.2)	18 (10.0)	155 (28.7)	2.4
Production	115 (32.0)	95 (52.5)	210 (38.9)	2.8
Maintenance/ sanitation/ catering	43 (12.0)	11 (6.0)	54 (10.0)	2.3
Job position				
Manager/supervisor	88 (24.5)	20 (11)	108 (20)	1.3
Non-manager/non-supervisor	271 (75.5)	161 (89)	432 (80)	2.9
Health status outcomes				
BMI (kg/m^2)[b]				
Normal weight	80 (22.3)	76 (42.0)	156 (28.9)	2.3
Overweight	191 (53.2)	69 (38.1)	260 (48.1)	2.3

Obese	88 (24.5)	36 (19.9)	124 (23.0)	3.5
Central obesity [c]				
Normal	188 (52.4)	78 (43.0)	266 (49.2)	1.8
Centrally obese	171 (47.6)	103 (57.0)	274 (50.8)	3.2
Hypertension [d]				
Not hypertensive	290 (80.8)	168 (92.8)	458 (84.8)	2.6
Hypertensive	69 (19.2)	13 (7.2)	82 (15.2)	2.3
Lifestyle characteristics				
Smoking status				
Never smoked	183 (51.0)	89 (49.2)	272 (50.4)	2.3
Former smoker	126 (35.0)	44 (24.3)	170 (31.5)	2.9
Current smoker	50 (14.0)	48 (26.5)	98 (18.1)	2.8
Alcohol (units/week)				
No drink	75 (20.9)	54 (29.8)	129 (23.9)	2.8
1 - <7	61 (17)	40 (22.1)	101 (18.7)	2.5
7 - <14	48 (13.4)	16 (8.8)	64 (11.9)	2.2
14 - <21/>21	49 (13.6)	5 (2.8)	54 (10)	2.4
Missing	126 (35)	66 (36.5)	192 (35.5)	
Physical activity				
Low	209 (58.2)	21 (11.6)	230 (42.6)	2.4
Moderate	78 (22.6)	76 (42.0)	154 (28.5)	1.8
High	69 (19.2)	82 (45.3)	151 (28.0)	3.5
Missing	3 (0.8)	2 (1.1)	5 (0.9)	
Daily salt intake				
≤6g/day	208 (58.0)	121 (66.9)	329 (61.0)	2.5
>6g/day	150 (41.8)	59 (32.6)	209 (38.7)	2.7
Missing	1 (0.2)	1 (0.5)	2 (0.3)	
DASH score (diet quality)				
High	112 (31.2)	92 (50.9)	204 (37.8)	1.9
Low	241 (67.1)	88 (48.6)	329 (60.9)	3.0
Missing	6 (1.7)	1 (0.5)	7 (1.3)	
Nutrition knowledge				
High	47 (13.1)	39 (21.5)	86 (15.9)	2.5
Low	312 (86.9)	142 (78.5)	454 (84.1)	2.7

a = Other: any other White, Black or Asian ethnicities including mixed backgrounds

b = BMI: underweight = ≤ 18.49; normal weight = 18.50 - 24.99; overweight =25.00 – 29.99; obese = ≥ 30.00

c = Central obesity: average mid-way circumference ≥ 94cm for men or ≥ 80cm for women

d = Hypertension: average systolic blood pressure $\geq$ 140 mmHg or average diastolic blood pressure $\geq$ 90 mmHg

The variance inflation factor (VIF) command was applied in order to check for the presence of multi-collinearity between the diet quality, physical activity, BMI and central obesity variables. The VIF values computed were all less than 10, indicating the presence of minimal levels of correlation between the variables. A zinb regression model was employed to investigate what health status outcomes and lifestyle factors influence the frequency of workplace absences. The results of the zinb are provided in Table 4 and as the model includes a splitting function, the table is divided into two parts; the binary logit model and the negative binomial regression of the potential and actual number of absent days. The negative binomial regression generated statistically significant results for the variables job position, central obesity, physical activity and diet quality. Statistical significance was observed at the 5% level of significance. The results indicate the presence of a negative relationship between the frequency of days absent and being in a managerial or supervisory position. This negative relationship is also reflected in the higher mean number of predicted days absent for managers/supervisors (1.3 days) versus non-managers/non-supervisors (2.9 days). A negative relationship was also observed between frequency of days absent and engaging in moderate levels of physical activity levels which was again mirrored in the mean number of predicted days absent for physical activity levels (low: 2.4 days, moderate: 1.8 days and high: 3.5 days). Similarly, consuming a high quality diet was negatively associated with frequency of absenteeism and the predicted number of days absent was lower for those consuming a high quality diet (1.9 days) compared to those consuming a low quality diet (3 days).

A positive relationship was observed between frequency of days absent and being centrally obese. This positive relationship was replicated in the mean number of predicted days absent for this group which was estimated to be 1.8 days for non-centrally obese employees and 3.2 days for centrally obese employees. No significant associations were found between absenteeism and age, education status, job type, marital status, BMI, daily sodium intake, alcohol consumption, smoking status and hypertension.

Table 4: Zero-inflated negative binomial model of absent days

	Logit Model			**Negative Binomial Model**		
Variable	**Coefficient**	**Robust Std. Err.**	**Z Statistic**	**IRR**	**Robust Std. Err.**	**Z Statistic**
Job position	0.20	0.64	0.31	0.50**	0.11	-0.73
Central obesity	-0.91	1.12	-0.81	1.72**	0.49	1.91
Physical activity	-0.84	0.60	-1.41	0.50**	0.15	-2.30
BMI obese	-0.63	0.99	-0.64	0.91	0.27	-0.29
BMI overweight	0.40	0.96	0.42	0.88	0.21	-0.49
Nutrition knowledge	-1.50*	0.90	-1.67	0.99	0.29	-0.01
Diet quality	0.10	0.67	0.16	0.64**	0.12	-2.29
Constant	-0.33	2.67	-0.12	2.22**	0.72	3.09

****** indicates significance at the 5% level**,** ***** indicates significance at the 10% level

The IRRs calculated in the negative binomial part of the zinb model correspond to the coefficients for the percentage change in the expected count for participants who may have been absent from work (Table 5). Being in a managerial or supervisory position decreases the expected rate of absenteeism by 50%. Similarly, regularly engaging in moderate levels of physical activity decreases the expected rate of absenteeism by 50% and consuming a high quality diet, decreases the expected rate of absenteeism by 36%. With respect to obesity, being centrally obese increases the expected rate of absenteeism by 72%.

The coefficients for the factor change in the odds of being in the ‘always zero’ group compared to the ‘not always zero’ group are also included in Table 5. Being in a managerial or supervisory position in work, increased the odds of not being potentially absent from work by 22%, holding all else constant. That is to say that the association between increased job responsibility and absenteeism remained, even after controlling for all other variables in the model. Being centrally obese decreased the odds of being present at work by 60%. While consuming a high quality diet increased the odds of not being absent from work by 11% and engaging in moderate physical activity levels increased the odds of not being absent from work by 57%. These associations persisted, even after controlling for all other variables in the model.

Table 5: The expected percentage change of absent days among employees

Count equation: % change in expected count for those *'not always 0'*				
	b Coefficient	**z Statistic**	**% Change**	**% StdX**
Job position	-0.68	-3.1	-49.5	-23.9
Central obesity	0.54	1.91	72.4	31.3
Physical activity	-0.69	-2.30	-50.0	-27.0
Diet quality	-0.44	-2.29	-35.5	-19.2
Binary equation: factor change in odds of *'always 0'*				
	b Coefficient	**z Statistic**	**% Change**	**% StdX**
Job position	0.20	0.31	22.2	8.4
Central obesity	-0.91	-0.81	-59.8	-36.6
Physical activity	0.84	1.41	56.9	31.8
Diet quality	0.10	0.16	11	5.2

b = raw coefficient, z = z-score for test of b=0, % Change = Percent change in expected count for unit increase in X, %StdX = Percent change in expected count for SD increase in X.

3.5. Discussion

This study revealed four primary findings with regards to what health status outcomes and lifestyle factors influence the frequency of workplace absenteeism. Central obesity was found to significantly increase the expected frequency of absenteeism. With regards to lifestyle behaviours, consuming a high quality diet decreased the expected frequency of absenteeism. Similarly, engaging in regular moderate physical activity also decreased the expected frequency of absenteeism. Furthermore, socio-demographic factors were also found to influence workplace absenteeism as increased job seniority reduced the expected frequency of absenteeism. Controlling for potential confounding socio-demographic, lifestyle and health characteristics did not alter these associations. The mean number of absent days was 2.5 days with a standard deviation of 4.5 days. In 2014, the Small Firms Association (SFA) reported that for large businesses in Ireland, the average annual absenteeism rate was estimated to be 2.3% (5.4 days) whereas in businesses with less than 50 employees, the rate was estimated to be 2.06% (4.7 days) (50). For these estimates, the SFA relied on self-reported estimates obtained from the Quarterly National Household Survey (QNHS) (122). This difference in reporting method may explain the lack of concordance between the estimates as bias may have been introduced through self-reporting.

Obesity has been identified as a significant predictor of absenteeism in previous research (46, 48, 95-98). Our overall findings support this consensus as central obesity was found to significantly increase the rate of and potential occurrence of absenteeism. However, it is important to note that the results of the previous research are based on studies that relied on the use of both self-reported absenteeism data and self-reported BMI measurements whereas our study findings are based on objective measures for both absenteeism and obesity. In further contrast to previous research, we reported no significant findings between BMI and absenteeism as significance was only observed with the measurement of central obesity. As previously indicated, there is a growing body of evidence that suggests reliance on BMI for general obesity diagnosis can lead to misclassification of adiposity (99). However, a dearth of evidence exists with regards to investigating the relationship between central obesity and absenteeism. In order to overcome issues with potential misclassification and to provide clarity on the appropriateness of obesity measures, future research should include robust objective BMI and midway waist circumference measurements. Consistency in future research will improve the comparability of the results.

Over 42% of the study population were reported to have the highest level of educational attainment (degree or post-graduate degree).This is somewhat comparable to the national average of 34.3% (123). However, given that the participating workplaces were based in highly technical industries (automotive, medical devices, IT and food and beverage), it could be argued that higher education levels among employees were to be expected. However, in contrast to previous literature, no association between educational attainment and absenteeism was reported (109, 110). Similarly, no association was found between job type and absenteeism. Our findings are consistent with current evidence that suggests increased job responsibility can influence workplace absenteeism and that greater decision authority is a predictor of lower absence rates (110, 111). Irrespective of job type, increased job responsibility and or job seniority in the workplace may serve as a deterrent for high rates of absenteeism and also actual occurrence of absences.

As previously mentioned, a great deal of ambiguity exists in the evidence base with regards to the influence of physical activity on absenteeism with both positive and negative associations being reported (96, 97, 100). Our findings of a negative association between absenteeism and physical activity may provide clarity to the evidence base due to the inclusion of objective absenteeism data. However, in order to accurately investigate the association between physical activity levels and absenteeism, the use of objective measures of physical activity through pedometers should be considered.

To date, no significant findings between absenteeism and diet quality have been reported (107). A novel finding that has emerged from this study is that consuming a high quality diet (i.e. high fruit and vegetable consumption and low fat, sugar and salt consumption) can significantly reduce the frequency of absenteeism and also the potential for absences to occur. Workplace health promotion polices that include guidelines for creating a healthy eating environment may provide favourable return on investment for employers through reduced frequency of absent days (124). Furthermore, three of the four principal findings influencing the frequency of absenteeism are modifiable health and lifestyle characteristics (i.e. obesity, diet quality and physical activity). This suggests that significant scope may exist to improve employee health outcomes and reduce absenteeism through the development of workplace health promotion policies. Such policies that are focused on increasing employees' physical activity levels and improving their diet quality (increasing fruit and vegetable consumption and reducing intake of fat, sugar and salt) should be critically considered by both employers and public health policy makers.

One of the key strengths of the current study is the use of recorded absenteeism data. Studies investigating predictors of absenteeism have relied heavily on self-reported absenteeism data. Using objective, recorded absenteeism considerably improves the quality and accuracy of the data and reduces the potential of measurement error, recall and social desirability bias. Similarly, objective measures for health status (BMI, central obesity and hypertension) were included and measured by trained research assistants. The four manufacturing workplaces involved in the study had similar structures and operations, ensuring employees had comparable demographics, health and lifestyle characteristics. There was very little missing data for this study, other than alcohol consumption. However, as this data was collected in the workplace, employees may have been reluctant to report their alcohol intake.

It is important to note a number of limitations of the current study. The FCW study only included measures of physical health and occupational stress and other mental health indicators were omitted. Occupational stress has been highlighted as a significant contributor to workplace absenteeism (125). The risk of obesity has been found to increase in work environments which are high-demand and low-autonomy (111). Previous research has suggested that such environments can induce the occurrence of occupational stress in employees (111, 126). Stress has been found to negatively influence food choice in terms of saturated fat and sugar consumption which can in turn lead to weight gain and subsequently absenteeism (111). Future workplace health promotion studies should consider including measures of occupational stress alongside physical health outcome measures.

The sample size (n=540) could be interpreted as small, however this is due to the exclusion criteria of the FCW trial. Exclusion criteria were focused on recruitment for the trial which may have influenced the findings of the present study. However, our study investigated the health status outcomes and lifestyle factors that influenced workplace absenteeism in a permanent manufacturing working population. To ensure there was an adequate response rate from employees per workplace, it was important that the study sample were contracted to work fulltime and on a permanent basis in their workplaces. Furthermore, due to the cross-sectional design of the study, the findings should be interpreted cautiously due to the potential for reverse causality. However, the consistency between the results and published evidence regarding predictors of workplace absenteeism adds strength to our findings. Although it is very likely that frequency of absenteeism is truly associated with central obesity, physical activity and diet quality, it is important to consider the potential for the presence of residual confounding in the data that was not captured or measured. Obesity is associated with a high number of adverse health implications which in turn increase the likelihood of absences occurring. It is possible that the association between central obesity and absenteeism may be driven by another factor arising from these adverse health implications that we have not considered in our data.

An additional limitation to consider is with regards to hypertension. The effect of controlled hypertensives is unknown as medication data was unavailable. Additionally, we need to acknowledge the potential presence of the 'healthy worker effect'. Despite employees being randomly selected to participate in the FCW study, this bias cannot be ruled out as healthy employees may have been more likely to participate in the study, leading to potential underestimation of associations. It is also important to consider that measurement bias and social desirability bias may have been introduced to the data when estimating diet quality as the data was self-reported.

3.6. Conclusions

In conclusion, the findings of this study can be used to guide and inform the development of workplace health promotion guidelines and polices. Specifically, the results indicate that improving modifiable health and lifestyle characteristics including obesity, physical activity and diet quality should be at the core of such guidelines and policies to potentially reduce rates of absenteeism. Owing to the growing prevalence of obesity and its association with absenteeism, workplace health promotion policies should be focused on promoting strategies that can effectively prevent and reduce employees' excess weight through increasing levels of physical activity and consuming a healthy diet. The implementation of informed workplace health promotion polices may benefit the employers in terms of lowering rates of absenteeism and may also benefit employees in terms of improving their health status outcomes.

4. BARRIERS TO AND FACILITATORS OF IMPLEMENTING COMPLEX WORKPLACE DIETARY INTERVENTIONS: PROCESS EVALUATION RESULTS OF A CLUSTER CONTROLLED TRIAL

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4.1. Abstract

Background

Ambiguity exists regarding the effectiveness of workplace dietary interventions. Rigorous process evaluation is vital to understand this uncertainty. This study was conducted as part of the Food Choice at Work trial which assessed the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination versus a control workplace. Effectiveness was assessed in terms of employees' dietary intakes, nutrition knowledge and health status in four large manufacturing workplaces. The study aims to examine barriers to and facilitators of implementing complex workplace interventions, from the perspectives of key workplace stakeholders and researchers involved in implementation.

Methods

A detailed process evaluation monitored and evaluated intervention implementation. Interviews were conducted at baseline (27 interviews) and at 7-9 months follow-up (27 interviews) with a purposive sample of workplace stakeholders (managers and participating employees). Topic guides explored factors which facilitated or impeded implementation. Researchers involved in recruitment and data collection participated in focus groups at baseline and at 7-9 months follow-up to explore their perceptions of intervention implementation. Data were imported into NVivo software and analysed using a thematic framework approach.

Results

Four major themes emerged; perceived benefits of participation, negotiation and flexibility of the implementation team, viability and intensity of interventions and workplace structures and cultures. The latter three themes either positively or negatively affected implementation, depending on context. The implementation team included managers involved in coordinating and delivering the interventions and the researchers who collected data and delivered intervention elements. Stakeholders' perceptions of the benefits of participating, which facilitated implementation, included managers' desire to improve company image and employees seeking health improvements. Other facilitators included stakeholder buy-in, organisational support and stakeholder cohesiveness with regards to the level of support provided to the intervention. Anticipation of employee resistance towards menu changes, workplace restructuring and target-driven workplace cultures impeded intervention implementation.

Conclusions

Contextual factors such as workplace structures and cultures need to be considered in the implementation of future workplace dietary interventions. Negotiation and flexibility of key workplace stakeholders plays an integral role in overcoming the barriers of workplace cultures, structures and resistance to change.

4.2. Background

The increasing prevalence of diet-related diseases is a major global public health problem. The growing burden on population health and unsustainable cost escalation is crippling healthcare systems worldwide (2, 38, 40, 127). The causal factors of diet-related diseases are inherently complex and require complex solutions (128). Behavioural interventions aim to improve dietary behaviours and reduce the associated burden of diet-related diseases at a population-level (10, 68, 129). The Medical Research Council (MRC) advocate the importance of combining the evaluation of outcomes and processes when evaluating complex interventions (10). Process evaluations monitor and evaluate the fidelity of interventions and can provide an in-depth understanding of factors that lead to the success or failure of implementing complex interventions (10, 130-132).

The workplace has been identified as an important health promotion setting as individuals spend long periods of time in their work environments and it also allows targeted health promotion programmes reach specific population groups (38, 67, 68, 133). The workplace provides access to a stable population in a controlled setting, making it conducive to the implementation of complex interventions (70). However, uncertainty exists regarding the effectiveness of complex workplace dietary interventions. Previous interventions have demonstrated limited efficacy with small effect sizes (7, 9, 12). Although, some studies have reported that workplace interventions can have moderate positive effects on dietary behaviour in terms of healthier food choices and increasing fruit and vegetable consumption (9, 12, 68, 134-

136), significant uncertainty remains regarding the long-term effects on dietary behaviour, health status outcomes and cost-effectiveness (12, 13, 68). These interventions failed to include detailed process evaluations but recommended that future workplace interventions should integrate rigorous qualitative and quantitative evaluation methods to explore reasons for ambiguous findings (7-9, 12, 134).

Very few comprehensive process evaluations of workplace dietary interventions have been conducted. Furthermore, few studies explore the opinions of those directly involved in workplace dietary interventions either as a decision maker or a participant. The evidence base consists mainly of process evaluations that evaluate low-intensity workplace health promotion interventions or workplace stress interventions. By design, low-intensity workplace health promotion interventions tend to focus solely on information provision and fail to investigate the effects of environmental approaches, such as food modification (70). In contrast, high-intensity interventions are complex in nature and typically consist of a number of different interacting components. These components can include both information provision and environmental approaches such as, food modification, restricting options and provision of real incentives (i.e. price discounts) (70, 137). These complex high-intensity interventions are informed by empirical evidence and theories and have a multi-level approach where they are specifically developed to target all stakeholders within an organisation (e.g. employers, caterers, employees) (10).

The available evidence on process evaluation of low-intensity workplace interventions has focused mainly on the effectiveness of interventions rather than on why interventions succeed or fail (77, 78). The limited available evidence indicates that contextual factors, particularly structural and organisational changes can greatly influence the implementation of workplace interventions (138-141). Evidence further suggests that in order to successfully implement workplace healthy eating interventions, it is vital to secure engagement by the catering team. Securing this engagement requires the research team to provide substantial support and understanding to the catering team (137). The complexities of the modern working environment including on-going structural changes and competing work projects have also been indicated as factors that can impede intervention implementation. In contrast, active involvement of managers in implementation, negotiation skills, consideration of workplace culture and assessing readiness for change can serve as facilitators of implementation (139). It has also been suggested that ensuring there is transparency in the implementation plan regarding roles and responsibilities of each team member can help facilitate intervention implementation (132, 139). Similarly, contextual factors were also identified as influential in the implementation of a health promotion intervention in four Danish industrial canteens and structural changes which resulted in downsizing, high employee turnover and job insecurity impeded successful implementation (141).

There are a number of change theories and frameworks which describe the implementation of interventions within organisations. These theories suggest that fully understanding processes of change within organisations is critical for the successful development and implementation of workplace health promotion initiatives (142, 143). Lewin's model of organisational change is one such theory and involves, unfreezing of current attitudes to change, implementing the new intervention and refreezing new attitudes and behaviour by supporting and reinforcing change (144, 145). This theory suggests that assessing organisational readiness for change and minimising the restraining factors of tacit organisational cultures are central for successful implementation of interventions and for achieving sustained change (142-145). Schein's theory on organisational change further suggests that in order to embed change, the intervention needs to become part of the culture of the organisation [31]. The principles of these theories are reinforced in implementation frameworks which outline the enablers and barriers to successful implementation within organisations (146). Stakeholder buy-in, organisational support, supportive organisational culture, monitoring and evaluation are defined as enablers of implementation. The external environment, resistance to change and vested interests are outlined as barriers to implementation within organisations (146).

To improve the implementation of complex, high-intensity workplace dietary interventions and achieve sustainable organisational change, it is imperative that factors which facilitate and impede the implementation process are identified by exploring the opinions of those directly involved (130). The aim of this study is to define and explore the facilitators of and barriers to the implementation of complex, high-intensity workplace dietary interventions from the perspectives of key workplace stakeholders, participating employees and research assistants delivering the intervention.

4.3. Methods

4.3.1. Context

The current study was carried out as part of the Food Choice at Work (FCW) study, a cluster controlled trial conducted in four large manufacturing workplaces in Cork, Ireland. Details of the FCW study have been published elsewhere (13). Briefly, the FCW study assessed the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination versus a control workplace on employees' dietary behaviours, nutrition knowledge and health status. Changes in employees' dietary intakes and health status (BMI, waist circumference and blood pressure) outcomes were measured at baseline, follow-up at 3-4 months and 7-9 months. As the focus of the FCW study was to implement a complex dietary intervention in an environment that could tolerate different interacting intervention components, workplaces were purposively selected and allocated interventions. Workplaces were deemed eligible if they were manufacturing workplaces who employed more than 250 employees, had a daily workplace canteen, located in Cork, represented on the Industrial Development Authority of Ireland (IDA) website and were able to commit to all components of the complex intervention for the duration of the study (13). In order to ensure that the participating workplaces and employees were representative of the general Irish workforce, demographic variables of non-participating employees were examined.

In the control workplace, data was collected at baseline and at each stage of follow-up. Participants in this workplace were informed that they were involved in a university-led study to observe employees' dietary behaviours. The second workplace received a nutrition education intervention which comprised of three elements; group presentations, individual nutrition consultations and the provision of detailed nutrition information (traffic light menu-labelling, posters, leaflets and emails). The third workplace received an environmental dietary modification intervention which consisted of five elements 1) menu modification (restriction of fat, saturated fat, sugar and salt), 2) increase in fibre, fruit and vegetables, c) price discounts for fresh fruit, d) strategic positioning of healthier alternatives and e) portion size control (13). Table 6 outlines the allocation of the interventions.

The intervention design was developed by the research team who had specific expertise in public health nutrition and dietetics and was advised by catering stakeholders (Catering Managers Association of Ireland (CMAI)). The research team collaborated with the workplace stakeholders (human resources (HR) and catering managers) to implement the FCW interventions within each individual workplace. Each workplace was assigned a research workplace leader who was based on-site and collaborated with workplace stakeholders to co-ordinate data collection for rotating shift schedules and monitor intervention adherence. Implementation was monitored and evaluated in all workplaces using a detailed process evaluation throughout the intervention period, analysing perspectives of management stakeholders, participating employees and research assistants. Steckler and Linnan's conceptual framework guided the process evaluation and was based on the components of context, reach, dose delivered, dose received, fidelity and recruitment (130).

Table 6: Allocation and description of FCW interventions

Workplace	Intervention	Description of interventions
Control (Food & beverage industry)	Control site	Monitored employees eating behaviours.
Education (Health industry)	Education	Nutrition education consisted of: 1) monthly group presentations, 2) individual nutrition consultations and 3) detailed nutrition information (shopping cards, posters, leaflets and emails), including the application of a healthy eating traffic light coding system to daily menus and vending machines. This displayed the number of calories and nutritional breakdown of the meal/food item.
Environment (Automotive industry)	Environment	Environmental dietary modification consisted of: 1) restriction of fat, saturated fat, sugar and salt, 2) increase fibre, fruit and vegetables, 3) price discounts on whole fresh fruit, 4) strategic positioning of healthier alternatives and 5) portion size control.
Combined (IT industry)	Combined	All elements of the education and environment interventions were implemented.

4.3.2. Participants

For the process evaluation, purposive sampling was used to recruit management stakeholders who were involved in the intervention either through initial consultation, decision-making or on-going collaboration with the researchers who collected data. Employees who participated in the intervention were selected using random number generation software. At baseline 27 face-to-face semi-structured interviews (13 managers and 14 employees) were conducted and 27 interviews (12 managers and 15 employees) were conducted post intervention implementation. Where feasible the same people were interviewed at follow-up stage, however this was dependent on availability of participants. Research assistants who conducted the interviews were involved in recruitment and data collection but were not known to the participants they interviewed. Table 7 outlines the characteristics of managers and employees who took part. Purposive sampling was used to recruit research assistants for the focus groups. All research assistants involved in the FCW study were invited to participate at baseline and at follow-up stage. Nine out of eleven research assistants took part at baseline and four out of six research assistants took part at follow-up. The reason for non-participation in the focus groups was the part-time availability of research assistants and there were fewer researchers employed at follow-up stage.

Table 7: Characteristics of baseline and follow-up interviews conducted with managers and employees

	Managers		Employees	
Workplace	**Baseline**	**Follow-up at 7-9 months**	**Baseline**	**Follow-up at 7-9 months**
Control	2 (Occupational health and admin managers)	3 (Occupational health and HR managers)	4 (2 male and 2 female)	4 (2 male and 2 female)
Education	3 (Occupational health, HR and catering managers)	3 (Occupational health, HR and catering managers)	3 (2 female and 1 male)	4 (3 male and 1 female)
Environment	4 (Managing director, HR and catering managers)	3 (Managing director, HR and catering managers)	4 (2 female and 2 male)	4 (2 male and 2 female)
Combined	4 (Occupational health and catering managers)	3 (Occupational health and catering managers)	3 (1 female and 2 male)	3 (1 male and 2 female)

For the interviews, individuals were contacted by email and follow-up telephone call when necessary. The focus group moderator emailed research assistants and invited them to participate. All participants provided written informed consent. Data were digitally recorded and transcribed verbatim. To preserve confidentiality, data were anonymised.

4.3.3. Topic guides

A co-investigator involved in the FCW study developed semi-structured topic guides for the interviews and focus groups. As previously outlined, Steckler and Linnan's conceptual framework was used to guide the process evaluation plan. Thus, the topic guides were based on the six components of the framework; context, reach, dose delivered, dose received, fidelity and recruitment (130). These topic guides were reviewed and refined by research assistants on the study. Pilot interviews that were conducted at baseline and at follow-up stage, overall study objectives, preliminary analysis of baseline data and researchers' experience of intervention implementation further informed the topic guides. For the interviews, the topic guides were used to explore facilitators of and barriers to the implementation of the interventions from the perspective of management stakeholders and employees. For the focus groups, the topic guides were used to explore the experiences of the research assistants delivering a complex intervention in the workplace.

4.3.4. Data collection

Semi-structured face-to-face interviews were conducted at baseline between February and April 2013 and at follow-up stage between April and July 2014. Interviews were conducted in the workplaces and lasted between forty and sixty minutes. The baseline focus group was conducted in May 2013 and the follow-up focus group was conducted post intervention implementation in August 2014. These were hosted in University College Cork by an independent moderator and lasted for one hour. An assistant moderator took observational notes. In the interviews and focus groups probes were used to initiate discussion when there was a pause and also to further explore points of interest.

4.3.5. Analytical tools

The framework approach was used for analysis of data (130, 147). This was considered appropriate as the process evaluation had pre-specified objectives while it also permitted the emergence of unexpected themes. Framework analysis is dynamic, allowing for change throughout the analytical process while its systematic nature provides transparency. This was beneficial as multiple researchers were involved in data collection, analysis and interpretation. The following steps were completed (130):

1) Familiarisation: Three researchers (SF, FG and CK) conducted the interviews. Researchers became familiar with the data by re-reading transcripts, audio tapes, field notes and observational notes. Recurring themes and initial ideas were noted in an analytical memo.

2) Identification of a thematic framework: Four researchers (SF, SMH, FG and CK) undertook initial coding of a selection of transcripts (one management stakeholder and one employee participant). These were subject to inter-coder reliability as one of the researchers (SMH) was not involved in data collection. Open coding allowed for an inductive approach. The preliminary coding framework was developed by discussing the convergence and divergence of codes. The researchers redefined this framework for subsequent stages of coding.

3) Indexing: This stage involved the indexing of specific parts of the data to correspond to the emerging themes. Data was imported into NVivo software (QSR International Pty Ltd) for coding. The refined coding framework was systematically applied to the data and the main thematic categories and sub-categories were formed.

4) Charting: The coded data was further abstracted and synthesised during the charting process by two of the researchers. This involved arranging themes into illustrative charts based on headings included in the thematic framework.

5) Mapping and interpretation: The charts provided a schematic diagram of the process evaluation which guided data interpretation. Interpretations were checked and discussed by two researchers. The interpretation of the themes was guided by the specific objectives of the study and also by the unexpected themes that emerged during analysis.

4.4. Results

4.4.1. Major themes

Four major themes emerged; 1) perceived benefits of participation, 2) negotiation and flexibility of the implementation team, 3) viability and intensity of intervention and 4) individual workplace structures and cultures. Depending on context, the latter three themes were found to have both a positive and negative impact on implementation and are discussed as either facilitators or barriers. Findings are presented from the perspective of management stakeholders, employees and research assistants.

4.4.2. Perceived benefits of participation

Both managers and employees highlighted the benefits of participating in the study. Managers had a desire to improve company image and foster employee loyalty while employees had a desire to improve their health. The perception of a long-term benefit rather than the benefit itself facilitated implementation in the short-term as it encouraged engagement and fostered buy-in. Verbatim examples of this theme are included in Table 8.

1. Concern with company image: Managers had a vested interest in ensuring successful implementation of the interventions as they had a strong desire to portray a positive company image to both industry and employees. Managers believed that participation in the study would be a means of achieving this objective. Managers wanted to depict an image of a progressive company both nationally and internationally in the manufacturing industry. This desire facilitated implementation as managers were

supportive of the interventions and they facilitated access to employees by releasing them from work activities to attend study appointments. Managers felt involvement in a university-led study would be regarded as prestigious by other companies. They expressed pride in being ‘chosen’ to participate and believed that it created a sense of elitism in the manufacturing industry. According to some of the researchers who collected data, a concern with company image motivated workplace stakeholders to provide recruitment and implementation support.

2. Managers’ personal interest: In some workplaces key workplace stakeholders expressed a personal interest in maintaining a healthy lifestyle. Occupational health stakeholders in the control and combined workplaces had a professional background in nursing and had great interest in supporting initiatives that would enhance health consciousness in the workplace. Similarly, in the education workplace, a HR stakeholder had professional training and interest in nutritional sciences. This interest was a driver for workplace participation and ensured that implementation of the interventions received organisational support.

3. Fostering employee loyalty: A desire to improve relations between employers and employees was a motivating factor for participation. Managers identified the study as an opportunity to improve relations with employees. In order to demonstrate their support for the study to employees, they released staff from work activities for appointments and provided resources for the study. They believed that driving health consciousness among employees would foster employee loyalty and boost morale

within the workplace which could result in financial benefits for the company by reducing absenteeism. It was anticipated that this could be achieved by managers promoting participation in elements such as the healthy-eating group presentations.

4. Health concerns among employees: The main reasons for employees participating included age concerns, individual health concerns (weight, cholesterol level, blood pressure, and digestive disorders) and lifestyle concerns. Older participating employees felt pressure to keep up with younger employees in their fast-paced working environments. Employees were seeking health improvements in an effort to curtail any negative effects of ageing and the need to 'slow down' their working pace. Employees appreciated the investment their employers made in the study as it provided them with a unique opportunity to have a nutritional consultation and a free health check-up during their working hours. It reassured employees that their employer concerns went beyond generating profit hence they felt obliged to participate.

Table 8: Theme of 'perceived benefits of participation' and verbatim examples

Theme	Verbatim Examples
Perceived benefits of participation	*1. <u>Concern with company image:</u> "We were one of the ones to be chosen, that's a huge cannon feather in our cap you know we're thrilled about that and you know again to promote the fact that it's not everybody that was selected…. we were chosen as a company for a particular reason and we're honoured to be included"* (HR manager, Environmental site - follow-up stage). *2. <u>Managers' personal interest:</u> "I would have been the person who pushed it to say 'let's go and do this, it's an opportunity, yeah'…having dieticians on site, having access to all this expertise you know, and it is a great pile of health promotion going on in the background"* (Occupational health, Control site – follow up stage). *3.<u>Fostering employee loyalty:</u> "If you're trying to convince employees that you're interested and trying to engage with them, show them you care about their health and well-being so that's a good engagement tool"* (Occupational health, nutrition education site - baseline stage). *"If we can keep our employees healthy, they'll be happier, produce better work, they'll hit their efficiencies a lot better and they're more likely to be in"* (HR, nutrition education site - follow-up stage). *4. <u>Health concerns among employees</u>: "We don't have the luxury in this modern day and age of getting to 54, in days of old you'd get to this age and you pull back a little, there's young and progressive people coming up underneath you and they take the pressure and that, that doesn't happen today. They are going to work people until they're 65"* (Employee, nutrition education site - follow-up stage).

4.4.3. Flexibility and negotiation

The researchers who collected data and who were involved in coordination and delivery of intervention elements were adaptable to dynamic workplace environments which facilitated implementation. This flexibility enabled the researchers to successfully negotiate with workplace managers on degrees of change that were agreeable to all parties and ensured the study received organisational support. Verbatim examples of this theme are included in Table 9.

1. Flexibility: The flexibility and adaptability of the researchers manifested itself in a number of ways. To facilitate timely data collection, it was critical for the researchers to adapt to the structure and practices of each worksite. Researchers were required to schedule appointments that complemented rotating shift patterns. Similarly, monthly group nutrition presentations were delivered multiple times each day to also complement rotating shifts. Data collection often occurred during busy times on site such as 'end of quarter'. On these occasions, employees frequently rescheduled appointments and researchers had to facilitate these late changes. At the outset, managers were concerned that the target-driven culture of manufacturing workplaces would not be suitable for implementing a study that requires employee interaction and significant logistical planning. However, researchers' adaptability to changes facilitated implementation.

2. Negotiation: The researchers also perceived negotiation as central to successful implementation. It was necessary for the researchers to negotiate a level of change that

was agreeable to mangers, caterers and the researchers themselves. In some instances, this resulted in changes to the planned intervention components or the scale of change. Effective communication with managers was necessary to reach a compromise with regards to what intervention elements were implemented and to what degree they were implemented, particularly for the environmental modification intervention. For example, the proposed portion size restrictions were heavily negotiated between the researchers and catering staff with compromises being made by all parties. Willingness to change among catering staff and researcher negotiation skills facilitated compromises being reached.

The researchers described how certain meals appeared to be non-negotiable in the environmental and combined workplaces. The cooked breakfast was part of the workplace culture and researchers found reaching an agreement on modifying this option challenging. A compromise was eventually reached on reducing the portion size of the cooked breakfast and cooking method was changed from frying to baking when possible. In this instance, workplace culture was identified as a barrier to full-scale implementation. Catering stakeholders anticipated employee resistance to change in response to changes being made to the breakfast options. This expectation persisted and impeded the implementation of some of the environmental modification elements.

3. High-level workplace management support: Due to the target-driven culture in the manufacturing industry, supervisors were reluctant to release production staff to attend appointments. A disruption on the production line could lead to knock-on effects for

overall site-level efficiencies. However, supervisors were instructed by managers to adapt to the demands of the intervention for the duration of the study period. To ensure that catering staff adhered to the intervention elements, management needed to reinforce the commitment that the workplace had made to the study. This was particularly evident in the environmental and combined workplaces, where environmental modification elements were implemented and more negotiation was needed in these workplaces. Stakeholder cohesiveness with regards to organisational support was central to achieving successful implementation.

Table 9: Theme of 'negotiation and flexibility' and verbatim examples

Theme	Verbatim Examples
Negotiation and flexibility	*1. Flexibility: "You need to adapt and be understanding because schedules do change so you go in with your full schedule and you mightn't get all of them or people last minute can't make it and you're getting annoyed when you're there on site waiting but out on site things are changing constantly so you really have to adapt"* (Researcher 2 - follow-up stage). *2. Negotiation: "Changing down to nearly half, we just couldn't, there would be uproar…we did a taste test, we put three plates out one with what we serve now, one with what UCC wanted us to serve and something somewhere in the middle that we felt we could serve and get away with, that's the way we made our choice"* (Occupational health, combined intervention site baseline stage). *"The breakfast option alright was something that you couldn't change too much. I suppose from their side they were just afraid that there would be a lot of backlash from the employees and there at the front line then*

	dealing with it" (Researcher 2 - follow-up stage). *3. <u>High-level workplace management support</u>: "I found it very, very hard to get product builders released for their sessions. That was a huge struggle for me, it's the team leaders and they're all about their metrics, they want to have, net efficiencies, be on target"* (Occupational Health - nutrition education site - follow-up stage).

<u>4.4.4. Workplace structures and cultures</u>

Individual workplace structures and cultures had an impact on implementation. In workplaces where senior management were actively involved in the study, it encouraged employee participation and secured more buy-in from production supervisors and team leaders. In the environmental workplace, the support of HR managers went beyond providing basic logistical support and HR contacts became involved in providing recruitment support. Organisational restructuring and a 'traditional' workplace culture had a negative effect on implementation. Verbatim examples of this theme are included in Table 10.

1. <u>Stakeholder buy-in</u>: Employees recognised the importance of receiving 'buy-in' from catering and management stakeholders in order for the intervention to be successfully implemented. This was also highlighted by the researchers who acknowledged their flexibility and willingness to change as a crucial facilitating factor. Enthusiasm of caterers towards the intervention further facilitated the progress of implementation. Support of the catering company in their workplace stemmed from caterers realising that involvement in the study could be a valuable learning opportunity and serve as a

foundation on which to enhance the knowledge of the catering staff. Catering stakeholders anticipated that their involvement would impress the head office of their catering company as staff will have the opportunity to apply the knowledge and skills they gained on how to produce healthy menus after the study period and in future interventions. This long term potential benefit garnered buy-in from catering stakeholders and facilitated intervention implementation as they were more invested in making the intervention a success in their workplace.

2. Production work: Both managers and employees perceived shift work to be a barrier to implementation. This was due to the logistical problems of arranging appointments for shift workers outside standard office hours. However, it emerged that it was the nature of production work rather than the shift cycles that impeded implementation.

3. Organisational restructuring: Conversely, a number of workplace factors were identified as aspects that impeded implementation. Two of the largest workplaces (education and combined) underwent major restructuring during the study. This involved the relocation of a large number of employees from both workplaces, which resulted in them being ineligible to participate in the study as they were no longer exposed to the intervention. As a direct result of the restructuring, a large proportion of the remaining employees changed shift patterns. In order to deal with these effects researchers had to liaise with management on how to best minimise loss to follow-up and had to adapt elements of the study to these changes. This involved researchers creating an appointment schedule to facilitate changes in shift work patterns to

encourage employees to complete all stages of data collection. The time it took to liaise with management regarding restructuring changes had a direct impact on the timeline of the study. Adjusting to the restructuring changes and the delays in recruitment meant that data collection timelines had to re-evaluated, however getting approval from the management stakeholders for these readjustments proved to be very time consuming.

4. Workplace culture: According to the researchers involved in data collection, the workplace culture provided challenges during implementation. This manifested itself particularly in the environmental modification site, with the majority of employees described as having 'traditional' eating habits. The cooked breakfast menu options and side portion of chips were described as part of the tradition of the workplace. The expectation of poor uptake of the interventions made catering stakeholders reticent to agree to all modifications. Catering stakeholders were cautious when agreeing changes which resulted in the cooked breakfast menu option not being fully modified in the workplace. However, as previously mentioned researchers overcame this by reaching compromises on method of cooking, portion size and reducing the number of days that chips were available in the workplaces.

Table 10: Theme of 'workplace structures and cultures' and verbatim examples

Theme	Verbatim Examples
Workplace structures and cultures	*1. Stakeholder buy-in: "We had really good contacts with HR, they helped with recruitment, they helped schedule some participants…. that was probably the easiest site in terms of scheduling and recruiting…. if someone didn't turn up all I had to do was go downstairs and tell one of the HR people and they would actually go and get the employee"* (Researcher 1 - follow-up stage). *2. Production work: "There's a big, discrepancy between the support staff and the people who work on the line, in that the support staff have that freedom to, to go to these things"* (Occupational health, nutrition education site -follow-up stage). *3.Organisational restructuring: "Those who are in charge they'd have the overall influence because they're the ones bringing in the stock and stuff, so they have to be behind it 100%. Like if there was opposition from the management that could hinder it"* (Employee, nutrition education site - baseline stage). *"Many employees they left the company and were moved to other departments, so it was hard to get them back for the last stage of the study but we got agreement from the managers in order to allow us to complete the last stage"* (Researcher 3 - follow-up stage). *4.Workplace culture: "Well it's another concern, its more rural here, people are more conservative about their food…we've been asked over the years for stuff like Panini's, honestly, I'd give them a week and they just don't go" (*Catering Manager, environmental site baseline stage).

4.4.5. Viability and intensity of interventions

The design of the interventions also impacted how they were implemented. The sustainability of the interventions and the ability of workplaces to tailor the interventions to meet the needs of their workplace facilitated implementation. The anticipated employee resistance to change in response to the environmental modification impeded implementation of the interventions. Interventions intensity also affected implementation. The high-intensity intervention (combined intervention) was well received by employees. However, the low-intensity interventions (education and environmental) did not meet employee expectations which impeded implementation. Verbatim examples of this theme are included in Table 11.

1. Sustainability of interventions: Intervention design had impact on implementation. At the outset, catering staff were apprehensive about implementing environmental modification elements as they anticipated it would cause a significant increase in workload. However, it transpired that any extra workload initially created dissipated once the intervention was in place and as a result the study was easier to maintain. Environmental modification elements became part of the normal catering routine within workplaces even after the study, with workplaces sustaining elements. Similarly, the environmental modification site maintained the healthy default menu options, increased the number of 'chip free' days per week in the workplace and removed free-flowing sugar and salt from the canteen. The catering staff in the combined intervention decided to keep elements that modified the nutritional quality of food in terms of fat, saturated fat, sugar and salt.

However, there was a perception among the researchers that catering stakeholders in the combined workplace found the initial implementation of the intervention burdensome in terms of extra workload. Researchers suggested that this caused a delay in implementation at the outset which was overcome through negotiation of elements that were more feasible for the catering staff to implement.

2. Tailoring of interventions: The advantage of being able to tailor the intervention to address certain needs was also alluded to by the employees. An employee being able to 'pick and choose' to engage with certain elements was not an intended feature of the study design. This occurred naturally throughout the study as employees reported that different elements of the intervention worked for them, for example, some employees found the health eating chat table more beneficial to them compared to the monthly group nutrition presentations. Employees also appreciated that participation in the study was open to all employees in the workplace, regardless of job position. This inclusive study design which allowed employees to adapt elements to meet their own requirements was perceived as a key facilitating factor for implementation by employees and management stakeholders. The intervention created scope to positively impact all employees in terms of dietary behaviour, regardless of participation in the study with all employees being exposed to the intervention in the canteen.

3. Information at a glance: Employees outlined how the traffic light system enabled them to make informed decisions with regards to healthy or unhealthy menu options. It provided information at a glance in a fast-paced environment which was particularly

helpful to production workers as their lunch times were very restrictive. This visibility of the intervention was described as a talking point among employees and they discussed their clinical measurements, progress and feedback with each other. Displays of nutritional information in the canteen and the daily email of healthy options were considered effective. The traffic lights created a social desirability response as employees were reluctant to choose a menu option that was coded as red when they were eating in a group. It also emerged that since the study finished in the workplaces, employees and catering stakeholders found the absence of intervention very noticeable, mainly the traffic light coding system and the nutritional information that was displayed in the canteen. The design of the intervention in terms of its inclusive and visible nature was perceived to be a key facilitator for successful implementation.

4. Employee resistance to change: The potential for employee 'backlash' in response to choice restriction impeded implementation. Caterers anticipated that the implementation of choice restriction may create a sense of perceived powerlessness amongst employees. They also anticipated employee 'backlash' in reaction to the introduction of chip free days and reduced portion size. Some of these concerns were both anticipated and realised concerns. The combined intervention workplace reported that employees' resistance to change was largely in response to the removal of some of the unhealthy options on the menu. This impeded the implementation of the intervention slightly as caterers were reluctant to introduce a further chip free day that had been suggested during the negotiation with the researchers. However, catering stakeholders were determined to implement the agreed intervention elements to an

extent they thought was feasible. The expectation of resistance to change was one of the main reasons cited for negotiating the degrees of change in the workplace. There was a perception among researchers that the ‘backlash’ was not as great as expected. Researchers suggested that any resistance that occurred was due to a small minority in the workplaces and the catering company were capable of dealing with it.

5. Intervention intensity: Catering stakeholders and employees in the education and environmental workplaces felt that the study lost momentum towards the end of the study period. The interventions implemented in the education and environmental workplaces were low intensity by design compared to the high intensity intervention that was implemented in the combined workplace. Employees and catering stakeholders in the education and environmental workplaces felt that the interventions would have benefited from more regular stages of data collection and suggested that more emphasis should be placed on physical measurements and weight loss to increase intervention intensity. The low intensity interventions delivered in these workplaces did not meet employee expectations. Employees felt that delays in data collection and long stages of follow-up resulted in a loss of interest and focus in the study.

Table 11: Theme of 'viability and intensity of intervention design' and verbatim examples

Theme	Verbatim Examples
Viability and intensity of intervention design	*1. <u>Sustainability of interventions:</u> "It was much easier than I thought it was going to be. I was a little scared at the start of the changes that would have to be made, but it was fine, it was all quite manageable"* (Catering manager, environmental site - follow-up stage). *2. <u>Tailoring of interventions:</u> "Even though the study is over it still continued, there was no dramatic okay that's done go back to the old ways, pretty much there's a lot of things that we kept on board"* (Catering manager, combined intervention site - follow-up stage). *3. <u>Information at a glance</u>: "People are in a hurry so it was a perfect situation where you were rushing in and out you could still see at a glance what your options were in terms of healthy choices" (Occupational health, nutrition education site – follow-up stage).* *4. <u>Employee resistance to change:</u> "The glazed loin of bacon, we took it off for two weeks and we had something like 300 comment cards, it's like, 'where is bacon' it would always be on a Monday or Tuesday"* (Catering manager, combined intervention site - follow-up stage). *"They were afraid there would be backlash from the employees and they are at the front line dealing with it but, when we spoke again there wasn't too much backlash"* (Researcher 2 - follow-up stage). *5. <u>Intervention intensity:</u> "It's not very regular, should I say and it's not very intrusive, you know what I mean… it's the idea of, you know, getting weighed in once a week and kind of like the competition type thing"* (Employee, environmental site - follow-up stage).

4.4.6. Barriers and facilitators to each intervention

The four aforementioned themes (perceived benefits of participation, negotiation and flexibility of implementation team, viability and intensity of interventions and individual workplace structures and cultures) were the major themes to emerge from the process evaluation. However, it is also important to acknowledge that a number of barriers and facilitators specific to each intervention (arm of the study) also emerged during analysis. These intervention specific barriers and facilitators are included in Table 12.

Table 12: Barriers to and facilitators of implementing each intervention

	Barriers	**Facilitators**
Education	-*Nutrition education elements:* Due to the dynamic, target-driven nature of the workplace, it was difficult to secure engagement with manufacturing employees with nutrition consultations and group presentations.	- *Visibility of the nutrition education elements*: The traffic-light menu labelling provided information at a glance and facilitated employee engagement with intervention elements.
Environment	- *Absence of nutrition education*: The study did not meet employee expectations as they were not receiving detailed nutrition consultations. The study was not as intensive or as intrusive as employees had envisaged it to be.	- *Adaptability of the intervention:* Menu modifications were tailored to consider cultural preferences of the workplace. - *Sustainability of the interventions:* The menu modifications became ingrained in the workplace culture as they were easy to carry out.
Combined	- *Group nutrition presentations:* Due to the target driven culture of the workplace, it was not possible for production staff to engage with the group nutrition presentations as they could not leave the production line.	- *Adaptability of the intervention:* The way in which scheduling of physical assessments, menu modifications and nutrition education could be tailored to meet the needs of the workplace facilitated implementation.
Control	- *Absence of intervention elements:* The absence of intervention elements contributed to employee attrition throughout the follow-up stages as employees became disengaged with the study.	- *Monitoring of employees:* Provision of dietary recalls and physical assessments encouraged employee engagement as employees felt like they were receiving a free regular health check.

4.5. Discussion

This study aimed to establish what factors facilitated or impeded implementation of complex workplace dietary interventions. Four principal themes emerged; perceived benefits of participation, negotiation and flexibility of the implementation team, viability and intensity of intervention design and workplace structures and cultures. Contextual factors were found to heavily influence implementation. Tacit workplace cultures including 'traditional' menu preferences and anticipated and realised resistance to change prevented full-scale implementation of the environmental intervention. The target-driven culture of manufacturing workplaces impeded implementation as the researchers involved in data collection experienced challenges in arranging appointments with employees. The results suggest that manufacturing production work rather than restrictive shift cycles impeded implementation of a complex workplace dietary intervention. Organisational restructuring caused delays to the study timeline, attrition and disruptions to schedules. These barriers persisted throughout the study but were eased by the flexibility and negotiation skills of the researchers. The adaptability of the implementation team was a vital facilitator for implementation and helped accommodate the impact of extensive organisational restructuring.

Despite consensus in the literature that workplace dietary process evaluations should be conducted concurrently with evaluations of outcomes, the current evidence base is extremely limited (78). However, findings from this study are consistent with process evaluations of other types of organisational interventions. The structural environment can act as a major barrier to implementation if it cannot tolerate the intervention that is being implemented (146). Previous research indicates that contextual factors have significant influence on the implementation of workplace interventions. Complexities of the modern working environment including structural changes, competing projects, employee turnover and downsizing have all been outlined as potential barriers to implementation (139, 141). Workplaces are dynamic environments and their contexts cannot be controlled. The flexibility and adaptability of the researchers were important factors that helped the study overcome contextual barriers (137).

The findings are consistent with research that suggests stakeholder buy-in and supportive organisational cultures facilitate implementation (137, 139, 141). Managers perceived benefits and personal interest in the study fostered their buy-in and support which facilitated implementation. Stakeholder consultation and buy-in is critical for successful implementation (146). The implementation team openly consulted with each other throughout recruitment, intervention allocation and intervention implementation. This consultation process was beneficial for the researchers collecting data and coordinating and delivering the intervention as they were able to assess the capacity and suitability of each workplace for particular intervention elements. The process also assisted in workplaces providing organisational support to the study. Supportive organisational structures and systems are a key enabler of successful implementation (146). This study reported the presence of strong organisational support from one of the workplaces whereby the HR manager assisted in recruiting and scheduling of employees for their appointments which facilitated timely implementation.

Our findings are in line with Lewin's theory of organisational change which suggests that sustained organisational change is achieved by workplaces achieving an appropriate balance between minimising restraining factors and promoting facilitating factors (143-145). Tacit organisational cultures such as resistance to change and fragmented relationships between workplace stakeholders need to be managed. Resistance to change is a key barrier to achieving sustainable organisational change (146). This stage can also be referred to as the 'Unfreezing' stage of the Lewin's theory whereby organisations need to recognise the need to change the current situation [31]. This was achieved through initial consultations between the research team and workplace stakeholders. The second stage is referred to as the 'Transition' stage and involves the actual implementation of the intervention which should promote new behaviours, values or attitudes. This was achieved by implementing the FCW interventions and in order to overcome resistance, negotiation on degrees of change occurred during the implementation process. Restrictive factors can be overcome by key workplace stakeholders reinforcing the benefits of participation and by negotiation and compromise to minimise negative internal politics. This step can also be referred to as the 'Re-freezing' stage where the change becomes fixed in the workplace culture of the organisation. Schein's theory of organisational change is also reflected in the results as such positive reinforcement and minimising of restrictive facts can help the change to become embedded in the workplace culture [31].

Based on the results of this study, it is vital that future intervention teams consider individual workplace cultures and structural changes during the development and implementation of interventions. The effects of structural changes need to be monitored regularly throughout the study. Workplaces need to be able to tailor the intervention to meet their own specific needs with minimal effort (132). Consultation with key stakeholders should be an integral aspect of complex workplace interventions prior to implementation and can assist in considering the challenges of manufacturing work and in assessing an organisations readiness for change. Stakeholders need to be aware of the demands of the study and researchers need to determine if the workplace structure can tolerate all aspects of the intervention. Understanding the feasibility of implementing the FCW interventions will help researchers and workplace stakeholders anticipate future barriers of implementing multisite workplace dietary interventions.

Consideration also needs to be given to employee expectations. Employees' expectations of an intervention can impact how it is implemented and received. The control, education and environmental workplaces received low intensity interventions and employees in these workplaces felt that the momentum of the study was lost over time. Employees had anticipated an interactive intervention that would be of high intensity with more frequent physical assessments. This perceived loss of momentum impeded implementation as employees' interest in the study declined. As the employees were blinded to their interventions during the FCW trial, the researchers were unable to clarify the employees' expectations of the different interventions. However, in practice, the authors agree that employees should be made fully aware of what the intervention entails at the outset.

This study has several strengths and limitations. To ensure rigour, Guba's framework for ensuring trustworthiness in qualitative research was adhered to (148). This framework proposes four criteria for assessing trustworthiness; credibility, transferability, dependability and confirmability. Credibility is concerned with assessing the internal validity of the findings, ensuring they are congruent with reality (148). In an attempt to ensure credibility, well established research methods were used. These methods included the use of random sampling when appropriate, holding regular debriefing discussions during data collection and triangulating findings from different stakeholders. Transferability refers to the extent to which findings can be generalised or applied to other contexts (148). These findings may be generalisable nationally and transferable internationally as the workplaces included are multi-national manufacturing companies with similar worldwide structures and operations. Dependability addresses the reliability of the study and whether or not the same results would be achieved if the study were repeated (148). In this study dependability is concerned with the repeatability of the methods (148, 149). Both an in-depth methodological description which reported extensively on processes used and a comprehensive description on how changing contexts affected the implementation of interventions were provided.

The fourth construct of confirmability is concerned with the objectivity of the research (148). In this study, researcher bias cannot be ruled out as some of the authors were involved in the overall FCW study and were familiar with participants. Efforts were made to remain as objective as possible with researchers conducting interviews in workplaces that they did not visit for data collection, therefore they did not know the interviewees.

Furthermore, there were a number of members of the multidisciplinary FCW research team involved in the analysis and interpretation of findings which further reduced the potential for researcher bias. In addition, the inclusion of an inter-coder during analysis also helped reduce the potential for researcher bias. However, the inclusion of respondent validation may have been useful as respondents' interpretation of emerging results can help refine findings and strengthen conclusions.

4.6. Conclusion

The findings of this study can be used to support the argument that process evaluations should be carried out concurrently with effectiveness studies for workplace interventions (78). This study demonstrates how process evaluations can be used to explore factors that may influence implementation in controlled intervention studies and highlights the complexities associated with implementing complex workplace dietary interventions. Perceived benefits of participation, stakeholder buy-in and organisational support are intrinsic facilitators of implementing workplace dietary interventions. Flexibility and negotiation play a pivotal role in overcoming the barriers of individual workplace cultures, structures and resistance to change. Interventions also need to be adaptable as the manufacturing companies need to tailor interventions to meet specific structural and cultural requirements of their workplaces. Workplace stakeholders play a central role in achieving organisational change by reinforcing benefits and providing fundamental organisational support. Cohesiveness between different stakeholders within the workplace and between the implementation team (stakeholders involved in co-ordination and delivery of interventions and researchers involved in data collection and delivery of intervention elements) is essential for successful implementation. Intervention implementation within organisations is largely influenced by contextual factors. To achieve organisational change, these factors need to be carefully considered prior to implementation along with an assessment of readiness for change. This study provides an in-depth understanding of the implementation context to further illuminate the findings of the FCW study. The results may also inform the implementation of future workplace dietary interventions for the development of sustainable diet-related disease prevention and provide an opportunity for scaling of similar interventions for use in practice.

5. A COST-ANALYSIS OF COMPLEX WORKPLACE NUTRITION EDUCATION AND ENVIRONMENTAL DIETARY MODIFICATION INTERVENTIONS

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5.1. Abstract

Background: The workplace has been identified as a priority setting to positively influence individuals' dietary behaviours. However, a dearth of evidence exists regarding the costs of implementing and delivering workplace dietary interventions. This study aims to conduct a thorough cost-analysis of workplace nutrition education and environmental dietary modification interventions from the perspective of an employer.

Methods: Cost data were obtained from a workplace dietary intervention trial, the Food Choice at Work Study. Micro-costing methods estimated the costs associated with implementing and delivering the interventions for one year in four multinational manufacturing workplaces based in Cork, Ireland. The workplaces were allocated to one of the following groups: control, nutrition education alone, environmental dietary modification alone and nutrition education and environmental dietary modification combined. A total of 850 employees were recruited across the four workplaces.

Results:

The combined intervention reported the highest total costs of €31,108. The nutrition education intervention reported total costs of €28,529 which were considerably higher than total costs for the environmental dietary modification intervention were €3,689. Total costs for the control workplace were zero. The average annual cost per employee was; combined intervention: €62, nutrition education: €57, environmental modification: €7 and control: €0. Nutritionist's time was the main cost contributor across all interventions, (ranging from 53-75%).

Conclusions: Within multi-component interventions, the relative cost of implementing and delivering nutrition education elements is high compared to environmental modification strategies. A workplace environmental modification strategy added marginal additional cost, relative to the control. Findings will inform employers and public health policy-makers regarding the economic feasibility of implementing and scaling dietary interventions.

5.2. Introduction

Chronic diet-related diseases such as obesity, cardiovascular disease, type 2 diabetes and stroke continue to endanger population health worldwide (1, 5). The full impact of diet-related diseases extends beyond the population health burden to include a considerable financial burden which is attributable to escalating healthcare spending (2, 38, 150, 151). This financial burden is borne not only by society but also by employers as diet-related diseases have been linked to absenteeism and productivity loss in the workplace (4). In this environment of mounting healthcare costs and on-going financial constraints, emphasis is being increasingly placed on treatment of diet-related diseases rather than preventative measures (5). Consuming an unhealthy diet has been identified as one of the main modifiable behavioural risk factors for the development of chronic diet-related diseases (5). Dietary interventions that support low intakes of saturated fat, sugar and salt and high intakes of fruit and vegetables are considered to be one of the preferred cost-effective interventions for easing the burden (1, 5, 150).

The surrounding environment in which an individual lives and works has the potential to influence their health-related behaviour. It is widely accepted that modification of these surrounding environments can promote behaviour change at a population level (129). The workplace environment has been identified as a priority setting for the promotion of healthy dietary behaviours given that individuals are now spending up to two-thirds of their waking hours in their workplace (2, 38, 40, 67). Workplaces can facilitate the delivery and implementation of health promotion interventions by providing the necessary infrastructure and access to a stable population within a controlled environment (38, 40).

However, uncertainty exists with regards to the effectiveness of workplace dietary interventions (8, 152). Previous dietary interventions have demonstrated limited efficacy with small effect sizes (7-9, 12). There is some evidence to suggest that workplace nutrition education interventions can have modest positive effects on dietary behaviour in terms of intakes of fruit and vegetables (8, 152). However, there is a dearth of evidence regarding workplace dietary modification interventions (8, 11, 12). Furthermore, the evidence base regarding the costs associated with workplace dietary interventions is extremely limited as many interventions have failed to report cost data alongside effectiveness data (8, 12). Previous literature suggests that there is a need to accurately determine the associated costs of workplace interventions in order to reliably determine cost-effectiveness (12). Workplace dietary interventions have become a focal point on organisational agendas in an effort to reduce the costs associated with absenteeism and productivity losses however, the cost to employers associated with implementing and delivering these interventions remains largely unknown (67, 153).

The Food Choice at Work Study (FCW) was a complex workplace dietary intervention trial which assessed the comparative effectiveness of an environmental dietary modification intervention and a nutrition education intervention both alone and in combination versus a control workplace (13). This study will inform future cost-effectiveness analysis of the FCW interventions. As previously outlined, the financial impact associated with workplace dietary interventions have been poorly documented in the evidence to date. Hence, there is a need for a detailed exposition of costs for each intervention to be presented. The aim of this study is to provide a transparent assessment of the costs associated with implementing and delivering the FCW interventions over a one-year period. As the costs of implementing workplace interventions are usually borne by employers, the cost-analysis is conducted from the perspective of the employer and the intervention costs are measured against a control workplace. Findings provide a novel insight into the costs associated with workplace dietary interventions. Furthermore, the study will deliver accurate cost data which will assist both employers and public health policy makers in making evidence-based decisions regarding the economic feasibility of implementing dietary interventions and also on their potential scalability.

5.3. Materials and methods

5.3.1. Data source

A detailed description of the study design, intervention elements and methods of the FCW study has been published previously (13). In summary, a cluster controlled trial was conducted in four large multi-national manufacturing workplaces in Cork, Ireland over a nine-month period. A comprehensive list of Cork based manufacturing workplaces were obtained from the Irish Industrial Development Authority (IDA) website and were systematically screened for eligibility. Workplaces were deemed eligible to participate if they employed >250 employees, were located in Cork, had a daily workplace canteen and were able to commit to the intervention for the duration of the study. Four workplaces were purposively selected and allocated to the interventions accordingly. Employees were selected using random number generation software (Microsoft Excel) and were invited to participate if deemed eligible. Eligible employees were permanent, full-time employees who purchased and consumed at least one daily meal in their workplace. Employees were excluded if they did not work full-time, travelled regularly for work, were medically advised not to participate, were on long-term leave or were involved in an on-going diet programme external to their workplace. Further detail on workplace and employee recruitment has been published elsewhere (13).

5.3.2. Interventions

Participants in all workplaces underwent physical assessments (height, weight, midway waist circumference and resting blood pressure measurements) and 24-hour dietary recalls which were conducted by trained research assistants/nutritionists as per the Standard Operating Procedures (SOP) manual for the FCW study (15). In the control workplace data was collected at baseline and at each stage of follow-up with participants informed that they were involved in a university-led study designed to observe employees' dietary behaviours. Employees in this workplace also underwent physical assessments which incurred costs for both employee and nutritionist time. However as this was the control, nutrition education was not provided and no modifications were made to the environment. A nutrition education intervention was provided in the second workplace, an environmental dietary modification intervention was implemented in the third workplace and the fourth workplace received a combined intervention (both nutrition education and environmental dietary modification interventions).

The complex interventions were guided by a soft paternalistic 'nudge' theoretical perspective (89). The nutrition education intervention was designed to create positive reinforcement with indirect suggestions for healthy food choices in an effort to improve the employees' dietary behaviours. Elements such as the one-to-one nutrition consultations and calorie and traffic light menu labelling were designed to prompt conscious consideration of food choices. The environmental dietary modification interventions were guided by choice architecture (89). These elements were designed to prompt both conscious (repositioning of healthier alternatives) and unconscious (menu modification) thoughts. The intervention design was developed by the FCW research team (nutritionists/dietician) and advised by catering stakeholders (Catering Managers Association of Ireland (CMAI)). The research team collaborated with the workplace stakeholders (occupational health and catering managers) to implement the interventions within each workplace. The FCW nutritionist provided training to catering staff regarding compliance with the recommended menu modifications and portion size control, specifically for the environmental dietary modification intervention. Each workplace was assigned a research workplace leader who collaborated with workplace stakeholders to co-ordinate data collection for rotating shift schedules and monitor adherence to the intervention. Ethical approval was granted to the FCW study by the Clinical Research Ethics Committee of the Cork Teaching Hospitals in Ireland in March 2013.

5.3.3. Measuring intervention costs

All costs incurred from implementing and delivering the FCW interventions over a one-year period were measured from the perspective of the employers. A total of 850 employees took part in the FCW study (Control: N=111, Education: N=226, Environment: N=113 and Combined: N=400). The number of employees recruited per workplace was proportionate to company size. Costs were measured for 850 employees, however for the purposes of this study, total costs were standardised for a cohort of 500 employees per workplace. This was for ease of comparison as having the same sample size per workplace will allow employers to use the costs as a benchmark in similarly sized workplaces that are implementing dietary interventions. Similarly, standardising costs over one-year rather than 9 months (duration of intervention implementation) further increases the comparability of findings for employers.

In order to obtain an accurate estimate of costs associated with implementing and delivering the intervention outside of a trial setting, research costs (equipment used for carrying out physical assessments) were excluded from the analysis. Furthermore, the costs incurred through conducting physical assessments are not presented in the main results but are presented in the discussion of this study. A bottom-up approach, using micro-costing was employed to disaggregate the cost of each intervention. The resources consumed in each intervention were identified and the unit costs of the resources were multiplied by the quantities used (154). The FCW research team who were involved in the implementation of the interventions identified each intervention pathway and thus, each of the cost components to be measured. This identification occurred through a combination of interviews with the nutritionists, research assistants and employees and through referencing of workplace diaries that were kept by each workplace leader. Labour and material supply costs were the only two types of costs to be identified. These costs were subsequently separated into three phases, the first of which represented set up costs (costs incurred through intervention implementation). These were once-off costs and were therefore not annualised. The second phase of costs represented maintenance costs (costs incurred through intervention delivery) and the third phase represented physical assessment costs (costs incurred through employees undergoing physical assessments with research assistants). Five cost categories were identified for each phase:

1. *Nutritionist costs:* Staff costs for the nutritionist included the time it took for; food product and menu analysis; application of calorie and traffic light coding to menus; preparation of detailed dietary information; individual nutrition consultations; group presentations; healthy eating chat tables and monitoring adherence to interventions.

2. *Catering costs:* This category consisted of staff costs for the catering manager, head chef and catering assistants. This included the time associated with discussing and agreeing on menu changes and other intervention elements, the displaying of calories and traffic lights on menus and receiving training from the nutritionist regarding portion size control.

3. *Management stakeholder:* This category included staff costs for workplace staff who were involved in intervention implementation or delivery. Staff costs arose from time spent at meetings between the environmental health and safety manager (representative from occupational health department) and the nutritionist at the outset of the study and meetings that were held to discuss the logistics of the monthly group presentations and nutrition consultations.

4. *Employee costs:* These costs included the time associated with employees attending the individual nutrition consultations during working hours and also lost leisure time for employees attending monthly group presentations and the healthy eating chat table during lunch breaks.

5. *Printing and material costs:* This category was comprised of costs related to printing material and menu holders for the display of detailed nutrition information in the workplaces.

Table 13 contains a detailed breakdown of how the resources were identified, measured and valued for each of the five cost categories.

Table 13: Identification, measurement and valuation of cost categories

	Nutritionist costs			Catering costs			Management costs			Employee costs			Printing and material costs		
	# Units (hours)	€/unit	Source	# Units (hours)	€/unit	Source	# Units (hours)	€/unit	Source	# Units (hours)	€/unit	Source	# Units (materials)	*€/unit	Source
Education	875	27.50	Interview	HC: 10.0 CM: 33.4	29.65 44.48	Salary scale [155]	EHS: 5.96	51.68	Salary scale [155]	787.2	21.94	National average wage[156]	4,048	Range (0.03 to 3.00)	FCW expense reports
Environment	568.8	27.50	Interview	HC:8.1 CM: 4.0 CA:4.0	29.65 44.48 15.63	Salary scale (155) Job advert	EHS: 5.96	51.68	Salary scale [155]	362.7	21.94	National average wage(156)	254	Range (0.03 to 3.00)	FCW expense reports
Combined	953	27.50	Interview	HC:18.1 CM: 35.1 CA:4.0	29.65 44.48 15.63	Salary scale [155] Job advert	EHS: 5.96	51.68	Salary scale [155]	787.2	21.94	National average wage[156]	4,048	Range (0.03 to 3.00)	FCW expense reports
Control	489.2	27.50	Interview	-	-	-	-	-	-	362.7	21.94	National average wage(156)	-	-	-

Table 13 Legend:

#units = number of units used over a one-year period; €/unit = price per unit; HC = head chef; CM = catering manager, CA = catering assistant; EHS = environmental health and safety officer. *Represents a range of different print materials (leaflets, posters, menu displays, measurement cards, healthy eating guidelines booklet) all valued at a unit price, ranging from €0.03 to €3.00.

5.3.4. Valuation of intervention costs

These resources were valued in monetary terms using standard techniques (154, 157-159). For each intervention, the total intervention cost was estimated. The primary outcome was the net cost of each intervention (nutrition education, environmental dietary modification and combined) compared to the control workplace. Staff costs for the study nutritionist were estimated based on an hourly rate for a private nutrition consultancy service which was obtained through interview with a nutritionist. Similarly, staff costs for catering assistants were estimated using market prices which were sourced from job advertisements for food service assistant positions with the catering companies who participated in the FCW study. The Department of Health consolidated salary scales were used to estimate staff costs for the catering manager, head chef and environmental health and safety officer (155). The median point on the scales for a catering manager, a senior chef and a senior environmental health and safety officer were selected as recommended in national guidelines (Health Information and Quality Authority (HIQA)) (159). To adjust for associated non-pay costs employers PRSI (10.75%) was added to the mid-point of the pay range, the net pension cost (4%) was added to the direct salary cost and overhead costs (25%) were then added to estimate the total staff cost (159). These adjustments for non-pay related costs are outlined in the national guidelines (HIQA) (159). Hourly costs for each staff category were then subsequently calculated as per the Government Regulatory Impact Analysis (RIA) guidelines (160). Employee time was valued using the national average wage as specified by the Central Statistics Office (CS0) (156).

For printing and material costs, cost data were obtained from FCW expense reports which were made available by the FCW project manager. With regards to the implementation and delivery of menu modifications, no extra costs were incurred. All menu modifications (which were recommended by the FCW nutritionists) were within the existing budget predefined by the catering provider for that workplace.

5.4. Results

A detailed breakdown of the total costs associated with setting up and implementing the nutrition education intervention, the environmental dietary modification intervention, the combined intervention and the control over a one-year period for a cohort of 500 employees are contained in Table 14. Across each of the interventions, two principal types of costs were identified; 1) staffing costs (the nutritionist, management stakeholders from the workplaces, catering staff and employees) and 2) printing and material costs. Physical assessment costs were also identified as a significant cost across each of the interventions. However, as research costs were excluded from the analysis, physical assessment costs were omitted in the presentation of the total costs.

Table 14: Breakdown of costs of interventions and control

		Education Costs (€)	Environment Costs (€)	Combined Costs (€)	Control Costs (€)
Set-up costs	Nutritionist	566	2,434	3,041	-
	Catering costs	47	480	480	-
	Management stakeholder costs	103	103	103	-
	Printing and materials	1,019	85	1,019	-
	Employee time	53	53	53	-
	Sub-total	*1,788*	*3,154*	*4,696*	-
Maintaining costs	Nutritionist	14,487	330	14,157	-
	Catering costs	1,736	-	1,736	-
	Management stakeholder costs	205	205	205	-
	Printing and materials	282	-	282	-
	Employee time	10,031	-	10,031	-
	Sub-total	*26,741*	*535*	*26,412*	-
Physical assessments costs	Nutritionist	9,009	12,879	9,009	*13,453*
	Employee time	7,188	7,906	7,188	*7,959*
	Sub-total	*16,197*	*20,785*	*16,197*	*21,412*
	Total cost of intervention	***28,529***	***3,689***	***31,108***	***0***
	Annual cost per employee	***57***	***7***	***62***	**-**
	Total cost of intervention (including physical assessments)	*44,726*	*24,474*	*47,305*	*21,412*
	Annual cost per employee (including physical assessments)	*89*	*49*	*95*	*43*

For the nutrition education intervention set-up costs were reported at €1,788 (6.3% of total costs) and maintenance costs were reported at €26,741 (93.7% of total costs). The total cost of the nutrition education intervention was estimated at €28,529. The average annual cost per employee for implementing and maintaining the nutrition education intervention was estimated at €57.

The environmental dietary modification intervention reported set-up costs of €3,154 (85.5% of total costs) and maintenance costs were reported at €535 (14.5% of total costs). Total costs for the environmental dietary modification intervention were estimated at €3,689. The average annual cost per employee for implementing and maintaining the environmental dietary modification intervention was estimated at €7.

For the combined intervention set-up costs were reported at €4,696 (15% of total costs), and maintenance costs were reported at €26,412 (85% of total costs). Total costs for the combined intervention were estimated at €31,108. The average annual costs per employee for implementing and maintaining the combined intervention was estimated at €62. In the control workplace set-up costs and maintenance costs were non-existent as no intervention elements were implemented in the workplace. Physical assessment costs of €21,412 were reported, thus the cost per employee in the control workplace is zero.

Total costs were higher for the nutrition education intervention in comparison to the environmental dietary modification intervention. These higher costs were attributable to the delivery of one-to-one dietary counselling which was the main element driving the maintenance costs in the nutrition education intervention. This element, which was not provided in the environmental dietary modification intervention, required substantial investments of both the nutritionist and employees time. The cost of this element is reflected in the high nutritionist costs (€14,157) and high employee time costs (€10,031) for maintaining the environmental dietary modification. Similarly, the provision of detailed nutrition information and monthly group nutrition sessions incurred additional costs for the nutrition education intervention (€2,151 and €2,963). These elements included costs associated with printing and materials, nutritionist time and employee time.

The environmental dietary modification intervention reported marginal additional total costs when compared to the control workplace (€3,689). These additional costs were associated with the set-up (€3,154) and maintenance (€535) costs that were reported in the environmental dietary modification intervention. Set-up and maintenance costs were present in the environmental dietary modification intervention due to the time associated with nutritionists modifying menus, training of catering staff with regards to portion size control and monitoring adherence to menu and canteen modifications. Similar to the control, the maintenance of the environmental dietary modification intervention did not incur printing and material costs.

It can be observed that for each intervention, the nutritionist was the main contributor to the costs and accounted for the largest proportion of total costs: nutrition education intervention: 53%, environmental dietary modification intervention: 75%, and combined intervention: 55%. In the control workplace, the nutritionist and employees did not incur costs set up or maintenance costs as no intervention was implemented. In terms of the other staffing costs, employee time accounted for the second highest proportion of costs for each intervention (nutrition education intervention: 35%, environmental dietary modification intervention: 1.4% and combined intervention: 32%. Catering and workplace staffing costs and printing and material costs accounted for marginal proportions of the total costs.

When the physical assessment costs were factored into the analysis, total costs increased substantially for each intervention and increased to €44,726 for the nutrition education intervention; €24,474 for the environmental dietary modification intervention and €47,305 for the combined intervention. Total costs in the control workplace consisted exclusively of physical assessment costs (€21,412), as employees underwent physical assessments but did not receive any intervention elements. Physical assessment costs include costs incurred through employees undergoing physical assessments. Employee time and nutritionist time were the two categories of costs that were associated with physical assessment costs. This was due to the time associated with implementing the nutrition education intervention elements and employees receiving one-to-one dietary counselling (where they received advice on healthy eating guidelines). The inclusion of physical assessment costs resulted in the average annual cost per employee for implementing and maintaining the interventions increasing to €89 for the nutrition education intervention, €49 for the environmental dietary modification intervention, €95 for the combined intervention and €43 for the control.

5.5. Discussion

This study reports the results of a bottom-up costing study of complex workplace nutrition education and dietary modification interventions. As we are entering into an era where workplace health promotion dietary initiatives are garnering increasing attention, it is imperative that a detailed breakdown of the costs associated with these approaches is reported in a transparent manner. To our knowledge, this study is the first detailed cost-analysis of a complex workplace dietary intervention, therefore the findings can be considered novel. The combined intervention was revealed to be the most expensive intervention to implement and deliver (€31,108) and the nutrition education intervention (€28,529) was found to be considerably more expensive than the environmental dietary modification intervention (€3,689) to implement and deliver. When physical assessment costs are added to the total costs, the combined intervention remained the most expensive intervention to implement and deliver (€47,305), followed by the nutrition education intervention (€44,726) and the environmental modification intervention (€24,474). The findings indicate that the implementation and maintenance of environmental dietary modification strategies in the workplace add minimal additional cost to the control when compared to nutrition education strategies.

In the analysis of this study, physical assessment costs were purposively made distinguishable from the other categories of costs. As the FCW study was a research study, physical assessments were conducted in order to measure the clinical effectiveness of the different interventions. However, in 'real-world' settings such as workplaces, such outcome data would not need to be collected and the interventions could be implemented and delivered without physical assessments being carried out.

There is limited available evidence to suggest that workplace health promotion interventions that are based on the provision of nutrition information can result in modest improvements in terms of employee dietary behaviour and weight loss (8, 12, 153). However, despite this limited evidence and relatively modest outcomes, the provision of nutrition information has remained the primary focus of workplace health promotion initiatives (8). Employers are continuing to invest in nutrition information based workplace interventions that have demonstrated only limited effectiveness. Moreover, due to the lack of detailed cost data on such interventions, these investment decisions are being made without access to accurate cost data.

This study has revealed that the implementation and maintenance of environmental dietary modification interventions is less expensive than nutrition education interventions, irrespective of the inclusion or exclusion of physical assessment costs. These findings begin to address the paucity of evidence regarding the costs associated with the implementation and delivery of environmental dietary modification strategies in the workplace. There is consensus in the literature that an individual's surrounding environment has significant capacity to influence their health-related behaviour (129). Altering an individual's physical and social environment has been identified as one of the most effective ways of reducing the burden of diet-related disease and the main impetus for achieving behaviour change at a population level (161, 162). This evidence combined with our findings which indicate environmental dietary modification incurs minimal additional cost, suggests that such dietary modification strategies should be considered for implementation in workplaces rather than relying exclusively on traditional nutrition education strategies. The average annual cost per employee to implement and deliver the environment intervention is €7. This cost would be considered to be relatively inexpensive when borne by employers in large multinational manufacturing workplaces.

As previously mentioned, workplace health promotion strategies have become prominent features on organisational agendas both nationally (163) and internationally (5). The implementation of workplace ill-health prevention initiatives has been highlighted as a potential strategy for employers to improve employee health and to reduce escalating costs that are arising as a result of ill-health, absenteeism and lost productivity (163). The Health and Safety Authority advocate the development of a 'service-delivery model' that will support workplaces in the implementation of workplace health promotion and well-being programmes (163). Our findings suggest that environmental dietary modification strategies could serve as one such potential service-delivery model to support and facilitate employers in implementing workplace ill-health prevention and health promotion strategies at a minimal additional cost. The low maintenance costs (€535) for the environmental modification intervention would also suggest that such modifications strategies could be implemented in workplaces on a long-term basis. In addition, it can be observed that the environmental modification intervention requires marginal investments of employees' time. This low investment model would therefore not incur employee costs at the expense of the employer.

A key strength of this study is the use of bottom-up micro-costing methods to estimate the costs of each of the interventions at an individual level. Micro-costing is considered to be the most useful method to use when estimating the cost of a new health technology or intervention. Therefore, a high-level of precision in the cost estimates in the selected workplace settings can be ensured (154, 157, 158). Despite this precision in the cost estimates, it is important to acknowledge that these estimates were derived from specific dietary interventions that were implemented in atypical multinational manufacturing workplaces. Although the purposive selection of workplaces limits the generalisability of the results, the findings do provide some guidance on the potential cost of implementing similar interventions across different workplace settings.

5.6. Conclusion

This study offers a unique insight into the costs associated with both implementing and maintaining a complex workplace nutrition education and an environmental dietary modification intervention from the perspective of the employer. Findings will be used to inform a cost-effectiveness analysis of the FCW interventions. Due to the level of uncertainty in the evidence regarding the cost of workplace dietary interventions, providing a detailed exposition of the costs was of particular importance. An environmental dietary modification intervention incurs marginal additional costs when compared to the control. Nutrition education interventions and combined interventions are more expensive owing to the set-up and maintenance costs associated with the education strategies, demonstrating the need for careful consideration when selecting suitable education elements. Accurate cost data can be used to determine the potential scalability of such workplace dietary interventions and inform evidence-based decisions regarding their implementation. It is envisaged that the findings can be used alongside studies investigating the clinical effectiveness of workplace dietary interventions to inform employers and public health policy makers on how to achieve an appropriate balance between improving employee health outcomes and the economic feasibility of implementing complex workplace dietary interventions.

6. AN ECONOMIC EVALUATION OF COMPLEX WORKPLACE DIETARY INTERVENTIONS

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THIS PAPER IS TO BE SUBMITTED TO THE BMJ (SEE APPENDIX XX)

6.1. Abstract

Background

Obesity and obesity-related chronic diseases are associated with absenteeism in the workplace, incurring substantial costs for employers worldwide. Some employers are investing in workplace dietary interventions in an effort to curtail these escalating costs. The workplace is recognised as a priority environment to influence dietary behaviours and improve employee health. Yet, previous workplace dietary interventions have neglected to combine clinical effectiveness evidence with economic costs, thus the cost-effectiveness of workplace interventions remains unknown. Using evidence from the Food Choice at Work (FCW) study, a cluster controlled trial of a complex workplace dietary intervention, this study employs an economic evaluation of nutrition education, environmental dietary modification and combined workplace interventions.

Methods

An economic evaluation which compared the costs and outcomes of the complex workplace dietary interventions relative to a control was conducted. Cost and outcome data collected from the FCW study informed this economic evaluation which assumed a 9-month time horizon (length of intervention). Each of the interventions (education, environment and combined) was compared to a control workplace. This was achieved through firstly conducting a baseline cost-utility analysis (CUA) to measure the cost-effectiveness of the interventions in terms of quality-adjusted life-years (QALYs). Secondly, sensitivity analyses were conducted to test the robustness of the QALYs which consisted of performing three cost-effectiveness analyses (CEAs) using clinical measures to measure health outcomes (BMI, midway waist circumference and weight). Thirdly, a cost-benefit analysis (CBA) was employed, whereby the monetary value of absenteeism was employed so as to report the net benefit of the intervention(s) compared to the control, from the employers' perspective. A probabilistic sensitivity analysis, using a Monte Carlo simulation was also performed to assess parameter uncertainty.

Results

The baseline CUA indicates that each intervention (education (€37.85/QALY) environment (€5.88/QALY) and combined (€43.12/QALY)) is cost-effective when compared to the control in terms of incremental cost-effectiveness ratios. However, the cost-effectiveness acceptability curves (CEACs) demonstrate that the uncertainty in the incremental costs and effects translates into decision uncertainty for the environment intervention (50% probability of being cost-effective at €45,000/QALY threshold). Conversely, at no point between a ceiling ratio of €0 to €100,000 do the education and combined interventions have a higher probability of being cost-effective than the control. The results of the three secondary CEA confirm the baseline CUA results for each intervention. The environmental intervention reporting the lowest ICERs for: BMI (€14/kg/m^2), midway waist circumference (€3/cm) and weight (€7/kg). The CBA also

revealed that the environmental intervention offers the highest net benefit for employers (€145.82 per employee).

Conclusion

Environmental dietary modification interventions offer the most cost-effective approach for improving employee health outcomes and also provide a positive net benefit for employers. However, due to the considerable uncertainty that surrounds the existence and extent of differences in health effects between the environment intervention and the control, it is imperative that future research includes long-term outcomes to avoid capturing high initial costs of rolling out the interventions. Inclusion of long term outcomes would determine if improvements in the outcomes persisted into the future.

6.2. Background

Obesity and obesity-rated chronic diseases including cardiovascular disease (CVD), stroke and diabetes have been linked to absenteeism in the workplace (4, 164, 165). Furthermore, obesity has been identified as a significant predictor of both short-term and long-term sick leave (48). As a result, employers worldwide are facing unparalleled challenges as they attempt to cope with escalating costs attributable to increasing levels of obesity-related chronic diseases which are adversely affecting the health of their employees (6).

Workplace absenteeism incurs both direct and indirect costs for employers. Direct costs include sick pay schemes, medical referrals and the cost of replacing absent employees while indirect costs consist primarily of losses incurred through absenteeism which leads to reduced productivity (3, 51). Reports released by the Irish Business and Employer's Confederation (IBEC) have indicated that an estimated 11 million days are lost to absenteeism annually (50, 51). These absenteeism rates have a substantial financial impact with absenteeism due to illness estimated to cost Irish businesses €1.5 billion each year, equating to €818 per employee per year (3). This negative financial impact is mirrored in the United Kingdom (UK), where workplace absenteeism is estimated to cost £29 billion annually with a reported 131 million days lost to absenteeism in 2013 alone (52). Absenteeism costs, coupled with an increasing prevalence of obesity-related chronic diseases are placing a crippling financial burden on employers.

In an effort to halt the mounting costs associated with employee absenteeism, employers have been investing in workplace health and well-being programmes (53). The World Health Organisation (WHO) has identified the workplace as a priority setting for health promotion and also for positively influencing dietary behaviours (2, 40, 53). The workplace has the necessary infrastructure that is central for the successful implementation of workplace dietary interventions. This infrastructure includes access to a relatively stable adult population within a controlled environment which minimises the risk of attrition (70). With employees now spending up to two-thirds of their waking hours in their work environment, the workplace has the capacity to influence the physical, mental, economic and social well-being of employees and that of their families and wider societies (53).

Emerging evidence suggests that efforts to reduce the prevalence of obesity amongst employees may result in a positive financial return for employers (46, 166). Aside from being motivated by the potential financial gains, employers are experiencing increased pressure to invest in workplace health promotion (167). This pressure stems from a legislative standpoint whereby employers have a duty of care towards their employees (168, 169). However, recent qualitative studies have revealed that this pressure may also be driven by altruistic motives with employers feeling responsible for enabling the health of their employees (167, 170). Employers feel responsible for creating a healthy workplace environment that will meet their employees' growing expectations (167, 170). Similarly, employers have become increasingly concerned with portraying a positive company image to industry and to their employees and perceive the implementation of workplace health interventions as a means of successfully achieving this image (170, 171).

Recent research indicates that well designed high-intensity complex workplace dietary interventions have the potential to be effective at improving health outcomes of employees (8, 9, 11, 12). However, as the cost-effectiveness of these workplace dietary interventions remains unknown, employers are investing in workplace dietary interventions without being informed by reliable cost-effectiveness evidence. To date, workplace dietary intervention studies have failed to integrate clinical effectiveness evidence with the costs of implementing and delivering dietary interventions, which has impeded the critical investigation of their cost-effectiveness (8, 9, 12, 134, 152). In order to address this paucity of evidence, there is an urgent need to investigate the cost-effectiveness of complex workplace dietary interventions. Economic evaluations of such interventions will inform resource allocation decisions by identifying efficient use of scarce resources and will also allow employers and public health policy-makers to accurately measure the potential for a positive net benefit from these workplace interventions (154, 172).

The Food Choice at Work (FCW) trial was a large cluster controlled trial of complex workplace dietary interventions delivered in four similarly structured multinational manufacturing workplaces in Cork, Ireland over a nine-month period (13). A full description of the FCW trial is provided in chapter 1. Briefly, the FCW trial assessed the comparative effectiveness of a workplace environmental dietary modification intervention, a nutrition education intervention and a combined intervention (included elements of both the environmental modification and the nutrition education interventions). Effectiveness of the dietary interventions was investigated both alone and in combination versus a control workplace. Employing standard economic evaluation methodology and evidence from the FCW trial, this study aimed to assess the cost-effectiveness of a complex workplace dietary intervention using a multifaceted approach from an employer's perspective (154, 159, 173). Findings will provide employers, public health policy makers, national and international catering stakeholders and industry with robust cost-effectiveness evidence on complex workplace dietary interventions. The multinational manufacturing workplaces included in the study have similar worldwide structures and operations therefore, findings may be transferable across similarly structured workplaces.

6.3. Methods for conducting an economic evaluation

The following section of this chapter outlines the four different types of economic evaluations that can be undertaken and also presents a description of the methods for conducting an economic evaluation of competing healthcare interventions.

6.3.1. Conducting an economic evaluation

Healthcare systems worldwide are faced with many challenges, including the interlinked problems of rising healthcare costs and scarce resources. Rising healthcare expenditures reflect many different situations for example, rapid advancements in health technologies, inflation of wages and changes in population demographics and healthcare needs (174). These rising expenditure levels place infinite demands on finite resources, necessitating the need for choices to be made between competing technologies (health interventions) (154, 172). Economic evaluation provides a means of assessing the costs and benefits of new and existing interventions to inform healthcare decision making regarding adoption or reimbursement decisions and also research and development prioritisation (154, 175). This approach is grounded in welfare economics. Welfare economics is a branch of economics that is specifically concerned with maximising the welfare of society through the optimal allocation of resources. All resources have an opportunity cost, this is based on the principal that when resources are allocated in a certain direction, opportunities to do something different with the resources are foregone [28].

There are four different types of economic evaluation which compare the costs and the outcomes/benefits/effects of competing technologies under consideration. These are outlined below:

1) Cost-minimisation analysis (CMA)

2) Cost-benefit analysis (CBA)

3) Cost-effectiveness analysis (CEA)

4) Cost-utility analysis (CUA)

While all four economic evaluation methods measure the costs of technologies in monetary units, the measurement of outcomes differs across each type of economic evaluation (154). CMA is undertaken in instances when the benefits of competing interventions have been proven to be equal and the alternative with the lowest net cost is favoured. In CBA, both the costs and benefits of competing interventions are assessed in monetary units, allowing for the direct comparison of incremental costs and incremental outcomes and estimation of net benefit. In CEA, interventions that produce similar health effects are compared and outcomes are measured in natural units such as life-years gained or a reduction in body weight etc. In CUA, a common outcome measure capturing quality and quantity of life, allowing for comparison between different interventions is used. In such instances, the outcomes are measured using a utility measure. Quality-adjusted life-years (QALYs), which represent both the quality and the quantity of life lived are the most frequently used health outcome measure in CUA (154). Alternative outcome measures, such as Disability-adjusted life-years (DALYs), which represent the sum of the years of life lost from premature death and years lived with disability are used less frequently in CUA (154). In both CEA and CUA the incremental cost of an intervention is compared to the incremental health improvement (health benefit of the intervention).

A summary of the key distinguishing features of these four economic evaluation methods, including the economic summary measures that are commonly used for each method, is included below in Table 15. Appendix 2 also contains further descriptions of each of these types of economic evaluations.

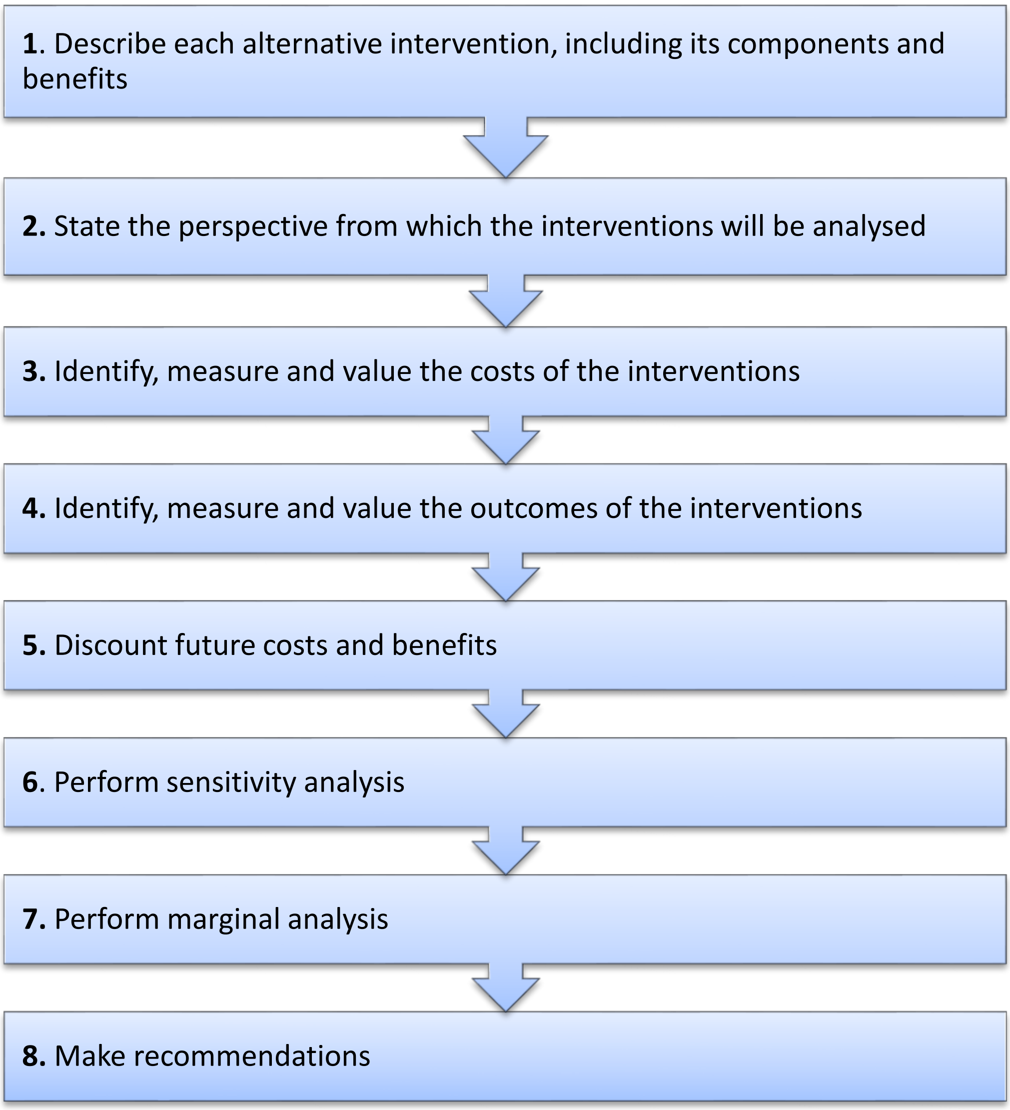
Table 15: Different types of economic evaluation

Economic Evaluation	Technologies Compared	Measurement of Costs	Measurement of Outcomes	Economic Summary Measure
Cost-minimisation analysis	Compares net costs of technologies that have demonstrated equal effectiveness	Monetary	Outcomes have demonstrated equivalent effectiveness	Net Cost
Cost-benefit analysis	Compares technologies with different outcomes (both health and non-health outcomes)	Monetary	Monetary	Net Benefit
Cost-effectiveness analysis	Compares technologies that produce a common health effect	Monetary	Natural units	Cost-effectiveness ratio (e.g. cost per reduction in BMI (kg/m^2))
Cost-utility analysis	Compares technologies with morbidity and mortality outcomes	Monetary	Year of life adjusted for quality of life	Cost per quality adjusted life year (i.e. incremental cost-effectiveness ratio (ICER))

6.3.2. Framework for conducting an economic evaluation

The framework proposed by Drummond et al (2005) for conducting economic evaluations, which is also consistent with the national HIQA guidelines, is one of the most widely used in the economic evaluation of health interventions (154). The framework outlines the eight stages involved in conducting a full economic analysis. Figure 5 outlines these stages.

Figure 5: Framework for conducting an economic evaluation



Source: Adapted from Drummond et al. (2005).

The first step of this framework involves providing a comprehensive description of each of the competing interventions and their components. The second step is concerned with the perspective of the economic evaluation, which is dependent on who is bearing the costs of the intervention and also on who is reaping the benefits of the intervention. Also here it is imperative to state the time-horizon of the economic evaluation in order for the costs and outcomes to be measured for the correct length of time (154).

The third step in the framework involves identifying, measuring and valuing the costs of the intervention. Identification of costs involves listing of all resources used in the intervention. The resources considered will be influenced by the perspective of the economic evaluation. Measuring costs involves the estimation of the quantities of the resources used in physical units and valuing costs is concerned with assigning monetary values to each of the resources costs (154).

The fourth step in the framework is concerned with identifying, measuring and valuing the outcomes of the economic evaluation. The outcomes that are measured are dependent on the perspective of the economic evaluation and also on what type of economic analysis is being conducted (Figure 5) (154).

The fifth step of the framework (154) is discounting future costs and benefits to present values to reflect society's rate of time preferences. Discounting is based on the principal that an individual will value future benefits and costs less than benefits or costs that occur at present.

The sixth step of the framework is concerned with testing the sensitivity of the results and is described in the next section of this chapter.

The seventh step involves conducting marginal analysis using the cost-effectiveness results. Incremental cost effectiveness ratios (ICERs) measure the additional cost per additional unit of health gain produced by one alternative intervention when compared to another [26]. The ICER represents the change in costs (change in costs, ΔC) when an alternative is compared to the comparator, divided by the change in health effects (change in effects, ΔE) when an alternative is compared to the comparator [89, 112]:

$$ICER = \Delta C / \Delta E \qquad (1)$$

As ICERs represent the cost per unit of outcome, they are used as a decision rule in allocation decisions [94]. The decision rule states that if a decision-maker can establish the willingness-to-pay value for additional units of the outcome, this value can be used as a threshold. If the ICER for an intervention under consideration falls above this threshold it will be considered too expensive and will not be recommended for reimbursement, whereas if the ICER for an intervention falls below this value, the intervention can be considered cost-effective and may be recommended for reimbursement (154).

The ICER formula can also be used to estimate the Net Benefit in CBA. By re-arranging the above ICER formula, the monetary value of the benefits is estimated by multiplying the ceiling ratio by the change in effectiveness (ΔE). The net benefit is then estimated by subtracting the difference in cost (ΔC) from the benefits measured in monetary terms. If the net benefit is greater than zero (positive net benefit), the intervention can then be considered cost-effective compared to the control [26]:

$$\textit{Net Benefit: (Ceiling ratio*}\ \Delta E) - \Delta C \qquad (2)$$

$$\textit{Net Benefit} > 0 \qquad (3)$$

Finally, recalling the framework outlined by Drummond et al. (2005), the eighth and final step is concerned with making recommendations regarding which intervention is cost-effective (154). These recommendations are based on the results of the previous seven steps. Cost-effectiveness is considered alongside the level of uncertainty surrounding the results.

6.3.3. Handling uncertainty in economic evaluations

In every economic evaluation various types of uncertainty can transpire. Uncertainties in economic evaluations are costly and increase the risk of an incorrect decision being made regarding the cost-effectiveness of a technology and its comparators (176). Incorrect decisions can have adverse implications whereby, access to beneficial technologies is delayed and society may be exposed to ineffective technologies. The methods for treating uncertainty differ with regard to its source and the type of economic evaluation.

Stochastic uncertainty is also referred to as first-order uncertainty or individual patient variability. It is concerned with the random variability that can occur in outcomes between identical patients (176). This refers to instances where individuals who are faced with the same probabilities and outcomes may experience the health technology differently. This is similar to heterogeneity which is concerned with the extent to which patient variability can be attributable to individual patient characteristics. Structural uncertainty is concerned with whether or not the structural assumptions in the model actually reflect reality (176). One-way sensitivity analysis can be used to examine the impact of the model assumptions. Another type of uncertainty that can transpire in an economic evaluation is parameter uncertainty. This refers to the precision with which an input parameter is estimated. Imprecision in parameters can arise in instances when small sample sizes have been used to estimate input parameters such as costs or utilities (176). To handle parameter uncertainty a probabilistic sensitivity analysis can be employed and is described in the next section.

6.3.3.1. Probabilistic sensitivity analysis

Probabilistic Sensitivity Analysis (PSA) provides a means of addressing uncertainty in the model by incorporating uncertainty from the input parameters into the economic model. Thus, the results facilitate an investigation of the uncertainty surrounding the output parameters and the adoption decision (176). There are three elements to performing a PSA:

1. Characterising uncertainty involves assigning probability distributions to the individual model parameters to reflect the uncertainty that is around them. The type of distribution that is applied is dependent on what type of data the

parameter is comprised of and how the parameter was estimated. Distributions that are commonly employed are normal, beta and gamma distributions (176).

2. Following the assignment of probability distributions, the second step of conducting a PSA is to propagate the uncertainty throughout the model. This step is achieved by employing a Monte Carlo simulation model whereby expected values are calculated a large number of times, with each simulation involving a random draw from each of the input parameter distributions. This generates a large number (e.g. 10,000) of sets of expected costs and effects that reflect the combined parameter uncertainty in the model and also represent a random draw from each of the input parameter distributions. For example, a Monte Carlo simulation which includes 10,000 iterations will provide 10,000 different values for the expected costs and effects (176).

3. The presentation of the implications of parameter uncertainty includes presenting 95th percentile ranges around the costs and outcomes. Incremental cost-effectiveness (ICE) planes and cost-effectiveness acceptability curves (CEAC) (176) are also employed to present parameter uncertainty. The next section in this chapter includes a description of both an ICE plane and a CEAC.

6.3.4. Presenting cost-effectiveness results

An incremental cost-effectiveness plane illustrates the uncertainty in the incremental costs and incremental outcomes generated from the PSA when an intervention is compared to an alternative. The ICE plane comprises of a four quadrant diagram which plots the incremental costs and effects of an intervention under consideration compared to its alternative (159). Incremental effects are plotted on the horizontal (east-west axis) and incremental costs are plotted on the vertical (north-south) axis [26]. If an ICER lies in the north-west quadrant it indicates that the intervention has higher costs and is less effective than the control and is said to be dominated by the control. If an ICER lies in the south-east quadrant it indicates that the intervention is less costly and more effective than the control and it is said to dominate the control. If an ICER lies in the north-east quadrant it indicates that the intervention has higher costs and is also more effective than the control. If an ICER lies in the south-west quadrant it indicates that the intervention is less costly and less effective than the control (159). In the latter two instances, a decision rule is required. To do so, a ceiling ratio/threshold value, representing how much society is willing to pay for the additional outcomes is used (154, 159). The ICER can be compared to this threshold value to establish if it can be considered as being cost-effective or not, thus determining if the intervention under consideration represents an efficient use of resources (177).

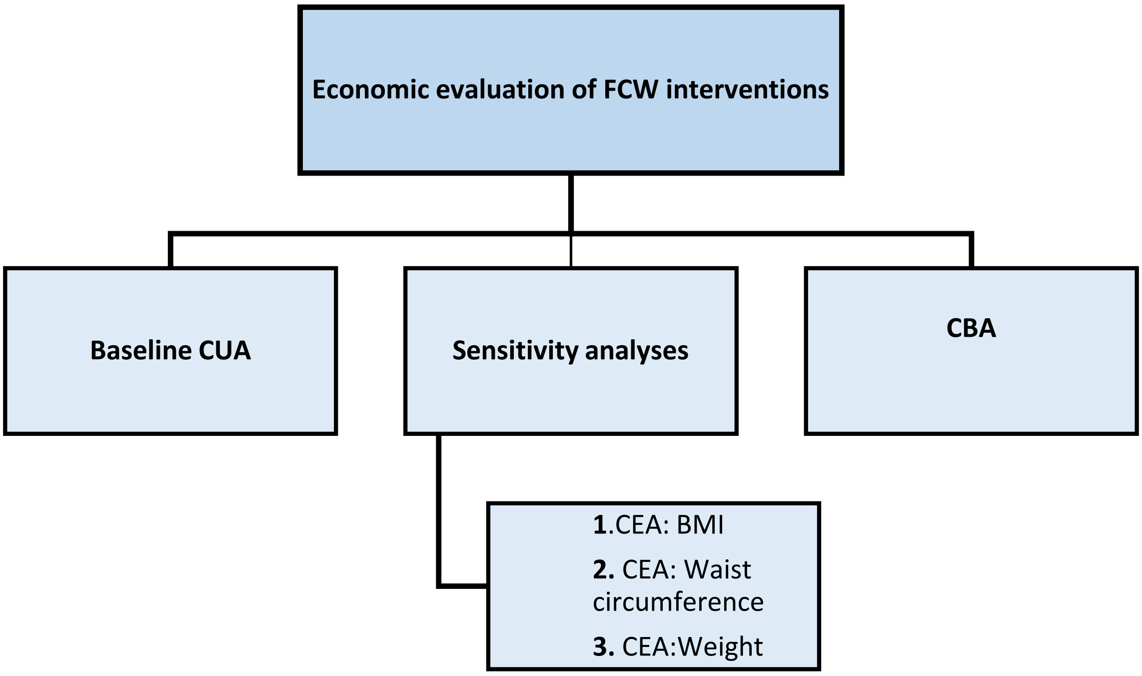
In Ireland in 2012, an explicit threshold of €45,000/QALY was established based on an agreement between the Irish Government and the pharmaceutical industry. The purpose of setting this threshold value was to generate substantial savings on new and existing medications. This threshold replaced the previous threshold value of €20,000/QALY (159, 178). However, in July 2016, the Irish Pharmaceutical Healthcare Association (IPHA) and the Irish Government concluded a new four-year framework agreement on the supply and pricing of medicines. Based on this new agreement, a cost-effectiveness threshold is no longer applicable within the Irish context. Reimbursement and allocation decisions regarding new and existing pharmaceuticals will be determined by the Health Service Executive (HSE) for the next four years (179).

Cost effectiveness acceptability curves (CEAC) are also used as a way of presenting cost-effectiveness results and provide a means of analysing the uncertainty surrounding the cost-effectiveness decision. Appendix 2 contains details of how to construct and interpret a CEAC. Briefly, using the results that are generated from PSA, CEACs graphically demonstrate the probability of an intervention being cost-effective for the available information, using a range of specified ceiling thresholds (e.g. €0 to €100,000) (180, 181). The probabilities represent decision uncertainty in the CEA and the thresholds represent the amount that society might be willing to pay for additional units of effectiveness (improvements in QALYs) (182). Uncertainty is then summarised as the probability that the technology is cost-effective at that specific ceiling ratio.

6.4. Economic model for the FCW study

The steps outlined in the framework described in Section 6.3 of this chapter were employed to conduct a multifaceted economic evaluation of the FCW complex workplace dietary interventions. To assess the cost-effectiveness of each of the interventions compared to the control, the three interventions (education, environment and combined) were compared to a control workplace. This was achieved through firstly conducting a baseline CUA to measure the cost-effectiveness of the interventions in terms of QALYs. Secondly, sensitivity analyses were conducted to test the robustness of the QALYs. This consisted of performing three CEAs using clinical measures to measure health outcomes (BMI, midway waist circumference and weight). Thirdly, a CBA was employed, whereby the net benefit of the intervention(s) compared to the control was estimated. This CBA is taken from the employers' perspective thus facilitating the translation of the outcomes into realisable benefits for business. Figure 6 illustrates a schema of the economic evaluation of the FCW interventions.

Figure 6: Schema of the economic evaluation of the FCW interventions



6.4.1. Description of the FCW interventions

Detailed descriptions of the study design, intervention elements, trial profile and attrition details of the FCW study have been published previously (13, 16) and are also outlined in Chapter 2 of this thesis. In summary, a cluster controlled trial was conducted in four large multi-national manufacturing workplaces in Cork, Ireland over a nine-month period. Recalling the framework proposed by Drummond et al. (2005), discounting is outlined as a step for conducting an economic evaluation of healthcare interventions [89]. As this economic evaluation was conducted for less than a year, only costs and benefits accrued in the immediate were considered therefore, discounting was not undertaken as part of this economic evaluation. No intervention elements were implemented in the first workplace, which was the control workplace. Monitoring of employees was the only action to occur in this workplace which involved participants undergoing physical assessments and 24 hour dietary recalls which were conducted by trained research assistants. These physical assessments included measuring participants' height, weight, midway waist circumference and resting blood pressure. Physical assessments and dietary recalls were conducted at baseline and at each stage of follow-up (13).

A nutrition education intervention (education) was provided in the second workplace and an environment dietary modification intervention (environment) was implemented in the third workplace. The fourth workplace received a combined intervention (combined) which included elements from both the education and the environment interventions. Participants in these workplaces also underwent physical assessments and 24 hour dietary recalls at baseline and each stage of follow-up. This economic evaluation took the perspective of the employers who implemented the workplace dietary interventions and considered a nine-month time horizon which represented the duration of the interventions.

6.4.2. Costs of the interventions and the control

The resources consumed in each intervention were identified, measured and valued. Chapter 5 of this thesis presents a cost-analysis of the workplace dietary interventions and provides a detailed exposition of the costs. In summary, the cost-analysis employed a bottom-up approach using micro-costing to disaggregate the costs of each intervention. The FCW research team involved in the development and the implementation of the interventions were consulted to identify measure and value the resources consumed under each intervention. In order to obtain an accurate estimate of costs associated with implementing and delivering the intervention outside of a trial setting, research costs (cost of equipment and travel costs) were excluded from the analysis. The costs were classified into three different phases representing set-up costs, maintenance costs and physical assessment costs. Five cost categories were identified for each phase: 1) nutritionist costs, 2) catering costs, 3) management stakeholder costs, 4) employee costs and 5) printing and material costs (Table 16).

Following identification of the resources consumed in each intervention, the unit costs of the resources were multiplied by the quantities used. Costs were valued in monetary terms using standard techniques, in line with the HIQA guidelines (154, 159). Staff costs for the nutritionist were estimated based on hourly rates for private nutrition consultants. Staff costs for catering assistants were estimated using market prices (sourced from Irish job advertisements). The Department of Health consolidated salary scales were used to estimate costs for catering and management stakeholders. Associated non-pay costs including, employers PRSI, net pension costs and overhead costs were also considered. Hourly costs for each staff category were calculated. Employee time was valued using the national average hourly wage (€21.94). Cost data for printing and material costs were obtained from FCW expense reports.

A breakdown of the total costs associated with setting up and implementing the FCW interventions over the duration of the study (9 months) is contained in Table 16. For the education intervention, set-up costs were reported at €1,755, maintenance costs were reported at €22,730 and physical assessments costs were reported at €12,572. The total cost of the education intervention was estimated at €37,058. The environment intervention reported set-up costs of €3,206, maintenance costs of €388 and physical assessments costs of €12,572. Total costs for the environment intervention were estimated at €20,527. For the combined intervention set-up costs were reported at €4,742, maintenance costs were reported at €22,468 and physical assessments costs were reported at €12,572. Total costs for the combined intervention were estimated at €39,782. Set-up and maintenance costs were non-existent in the control as no intervention elements were implemented. Total costs of €17,488 were reported, of which physical assessment costs accounted for 100%.

The findings indicate that the implementation and delivery of environmental dietary modification strategies in the workplace add minimal additional costs to the control when compared to nutrition education strategies. Physical assessment costs were purposively made distinguishable from the other cost categories as they were conducted as a means of measuring the clinical effectiveness of the different interventions. However, in 'real-world' settings such as workplaces, such outcome data would not need to be collected and the interventions could be implemented and delivered without physical assessments being carried out. Nevertheless, for the purpose of this economic evaluation, physical assessment costs were included in total costs as the physical assessments were an intrinsic element of the nutrition education and the combined interventions. To obtain a per employee cost, total costs were divided by the number of employees (n=517). The cost per employee for implementing and delivering the interventions for the duration of the intervention (9 months) was estimated at €71.68 for the education intervention, €39.70 for the environment intervention, €76.95 for the combined and €33.83 for the control.

Table 16: Costs for implementing and delivering complex workplace dietary interventions

		Education Costs (€)	Environment Costs (€)	Combined Costs (€)	Control Costs (€)
Set-up costs	Nutritionist	600	2,494	3,138	-
	Catering costs	41	490	490	-
	Management stakeholder costs	42	84	42	-
	Printing and materials	1,019	85	1,019	-
	Employee time	53	53	53	-
	Sub-total	*1,755*	*3,206*	*4,742*	-
Maintaining costs	Nutritionist	12,509	262	12,245	-
	Catering costs	1,573	-	1,573	-
	Management stakeholder costs	126	126	126	-
	Printing and materials	282	-	282	-
	Employee time	8,241	-	8,241	-
	Sub-total	*22,730*	*388*	*22,467*	-
Physical assessments	Nutritionist	7,175	11,003	7,175	*11,304*
	Employee time	5,397	5,930	5,397	*6,184*
	Sub-total	*12,572*	*16,933*	*12,572*	*17,488*
	Total cost of intervention (PSA 95th percentile ranges)	***37,058 (30,641 to 45,030)***	***20,527 (16,193 to 25,938)***	***39,782 (32,645 to 48,639)***	***17,488 (13,981 to 21,872)***
	Total cost per employee	***71.68***	***39.70***	***76.95***	***33.83***
	Total cost of intervention (excluding physical assessment costs)	***24,486***	***3,594***	***27,210***	***0***

6.4.3. Outcomes of the interventions and control

This economic evaluation consisted of a baseline CUA which measured the cost-effectiveness of the interventions in terms of QALYs. Secondly, sensitivity analyses were conducted which consisted of performing three CEAs using clinical measures to measure health outcomes (BMI, midway waist circumference and weight). Thirdly, a CBA was employed, whereby a monetary value of absenteeism was employed to estimate the net benefit of the intervention(s) compared to the control, from the perspective of the employer. See Figure 6 for a schema of the different types of analyses employed. This section describes the primary and secondary outcomes of this economic evaluation.

6.4.3.1. Primary outcome: QALYs

The primary outcome measure of this economic evaluation was an improvement in QALYs, which informed the baseline CUA. QALYs were measured using the EQ-5D questionnaire. Permission was obtained from the EuroQol Research Foundation in 2012 to use to EQ-5D questionnaire for the FCW study (Appendix 4 includes a copy of the questionnaire). The EQ-5D is a standardised, generic preference-based measurement tool which allows for health-related quality of life to be calculated as quality adjusted life years (QALYs) (183). Estimating QALYs involves the application of utility estimates to quantity of life years. Thus, QALYs incorporate both length of life and health-related quality of life from which a single index value is produced (184). The EuroQol Research Foundation provides cross-walk value sets for a number of countries. Single index values for each employee were calculated by employing the UK cross-walk value sets along with individual responses to the EQ-5D questionnaire. This index value is calculated using a linear 0 to 1 scale, where 0 indicates death and 1 indicates perfect health (183). Participants in each of the four workplaces self-completed the EQ-5D at baseline and again at 7-9 months follow-up. Of the 517 participants who completed the trial, complete EQ-5D data was available for 502 participants (93%), (Control: 57, Education: 102, Environment: 70 and Combined: 273).

Using Microsoft Excel software, t-tests were performed to calculate mean differences within each workplace in terms of QALYs from baseline to follow-up at 7-9 months. Table 17 details changes in effectiveness outcomes from baseline to follow-up at 7-9 months within the workplaces. Significant increases in QALYs were observed in the education (+0.03 QALYs, $p = 0.002$) and environment (+0.03 QALYs, $p = 0.001$) interventions. Small but insignificant increases were observed in the combined intervention (+0.01 QALYs, $p = 0.122$) and in the control (-0.01 QALYs, $p = 0.330$).

6.4.3.2. Secondary outcomes

Internationally recognised agencies (NICE, ISPOR etc.) advocate the use of QALYs when conducting economic evaluations. QALYs are a useful health outcome measure when healthcare systems are tasked with resource allocation decisions across a wide range of disease areas (185). Nevertheless, concerns regarding the reliance on QALYs in allocation decisions have been raised (186, 187). One such concern is that the comparison of quality and quantity of life contributes to the crudeness of QALYs and they may be insensitive to detect real changes in health-related quality of life (187). In such instances, it has been argued that it is more appropriate to include measures of health that are specific to the disease or the intervention that is under consideration. This is of particular importance in circumstances where the primary outcome of an intervention is a clinical outcome (176). Therefore, in order to test the robustness of the QALYs and to see if the results of the baseline CUA hold, secondary outcome measurements that were specific to the workplace dietary intervention, including absenteeism, BMI, midway waist circumference and weight were used to measure health outcomes. These secondary outcomes were employed in three one-way sensitivity analyses to test the robustness of the QALYs (see schema Figure 6).

The three clinical health outcomes were objectively measured in the FCW trial with the physical assessments conducted by the FCW research team (16). Data on these secondary outcomes was available for 517 employees across the four workplaces at baseline and end of the intervention (9 months) (Control: N=67, Education: N=107, Environment: N=71 and Combined: N=272). Using Microsoft Excel software, t-tests were performed to calculate mean differences within each intervention from baseline to follow-up at 7-9 months. Table 17 details changes in effectiveness outcomes from baseline to 7-9 months follow-up within the workplaces.

In terms of BMI, differences within interventions between baseline and 7-9 months follow-up were observed. At 7-9 months follow-up, there was a significant reduction in the BMI of participants (-0.44kg/m^2, p = 0.001) in the education intervention. Smaller non-significant reductions in BMI were observed in participants in the combined intervention (-0.07kg/m^2, p = 0.840), the environment intervention (-0.40 kg/m^2, p =

0.95). Within the control workplace an increase of 0.36 kg/m^2 (p = 0.60) was reported. With regards to differences between the interventions and the control at 7-9 months follow-up, small non-significant changes in participants' BMI were observed between the education intervention and the control (-0.80 kg/m^2, p = 0.820), the environment intervention and the control (-0.41 kg/m^2, p = 0.883) and the combined and the control (-0.43 kg/m^2, p = 0.29).

Small non-significant reductions in midway waist circumference were reported in the education intervention (-0.42 cm, p = 0.80), the environment intervention (-0.47 cm, p = 0.87 cm) and the combined intervention (-0.43 cm, p = 0.63) at 7-9 months follow-up. With regards to differences between the interventions and the control at 7-9 months, no significant differences were observed (education (-1.93 cm, p =0.62), environment (-1.98, p = 0.52) and combined (-1.94, p = 0.48). With respect to body weight, non-significant differences within in workplaces between baseline and 7-9 months were observed (education (-1.22 kg, p = 0.54), environment (-0.10, p = 0.97) and combined (-0.18, p = 0.88)). Small non-signification reductions in body weight were observed between each of the interventions and the control at 7-9 months follow-up (education intervention (-2.19 kg, p = 0.82), environment intervention (-0.88 kg, p = 0.87) and combined (-1.1 kg, p = 0.29).

Absenteeism outcomes from the FCW trial were employed so as to estimate a monetary value of absenteeism. Annual count absenteeism data for participants were obtained from the Human Resources department of each of the four workplaces. Absence data was available for the 517 participants who completed the trial. Frequency of absences was recorded in working days, based on an 8 hour working day. In order to measure whether the interventions had an impact on absenteeism in the workplaces, absence data was collected for a year prior to their implementation and for a year post implementation. Maternity or paternity leave absences were excluded from the analysis. Significant reductions in absenteeism were observed within the environment (-0.7 days, $p = 0.02$) and combined (-0.8 days, $p = 0.05$) interventions at 7-9 months follow-up. Smaller, non-significant differences were observed within the education intervention (-0.4 days, $p = 0.14$) and the control (+0.3 days, $p = 0.27$). No significant differences in absent days were observed between the intervention workplaces and the control at 7-9 months follow-up (education (-0.69 days, $p = 0.27$), environment (-1.05 days, $p = 0.64$) and combined (-1.12 days, $p = 0.75$).

6.4.3.3. Monetising absenteeism

As presented in the schema of the economic evaluation (Figure 6), this economic evaluation also consisted of a CBA, whereby the monetary value of absenteeism was employed so as to report the net benefit of the intervention(s) compared to the control, from the employers' perspective. IBEC have estimated the annual cost of absenteeism at €818 per employee [6]. As this figure is from 2010, it was necessary to adjust for inflation to estimate the cost of absenteeism for 2016. Using the Central Statistics Office Consumer Price Index (CPI) calculator to adjust for inflation, the cost of absenteeism was estimated at €864 per employee per year. In order to estimate a daily rate of absenteeism, this figure was divided by the average number of absent days (5.98) per employee [6]. This yielded a daily cost of absenteeism of €144.48 per employee. This estimate was used as the ceiling ratio in the CBA.

Table 17: Change in effectiveness outcomes from baseline to 7-9 months follow-up

Variable	Workplace	Baseline (mean (SD))	7-9 months follow-up (mean (SD))	Change from baseline to 7-9 months (SD)	p-value
QALYs[a]	Control	0.93 (0.12)	0.92 (0.13)	-0.01 (0.11)	0.33
	Education	0.92 (0.11)	0.95 (0.10)	+0.03 (0.12)	0.00**
	Environment	0.90 (0.12)	0.95 (0.11)	+0.05 (0.11)	0.00**
	Combined	0.93 (0.10)	0.94 (0.10)	+0.01 (0.09)	0.12
BMI (kg/m^2)	Control	27.6 (4.1)	27.9 (4.3)	+0.36 (1.20)	0.60
	Education	27.4 (4.5)	26.9 (4.0)	-0.44 (1.75)	0.00**
	Environment	32.0 (5.1)	30.3 (5.2)	-1.70 (1.10)	0.95
	Combined	27.2 (3.9)	27.1 (4.0)	-0.07 (1.01)	0.84
WC (cm)	Control	91.7 (12.1)	93.3 (12.7)	+1.51 (6.76)	0.50
	Education	92.1 (12.5)	91.7 (12.0)	-0.42 (4.79)	0.80
	Environment	92.8 (14.9)	92.3 (10.3)	-0.47 (2.82)	0.85
	Combined	93.6 (10.4)	93.2 (10.7)	-0.43 (3.70)	0.63
Weight (kg)	Control	80.3 (15.3)	81.2 (15.8)	+1.00 (3.4)	0.71
	Education	83.0 (15.4)	81.8 (14.6)	-1.22 (4.8)	0.54
	Environment	81.6 (17.9)	81.7 (18.3)	+0.10 (2.9)	0.97
	Combined	83.6 (14.2)	83.5 (14.2)	-0.18 (2.7)	0.88
Absenteeism (days)	Control	1.3 (3.4)	1.6 (4.9)	+0.3 (5.3)	0.27
	Education	2.6 (5.1)	2.2 (2.7)	-0.4 (4.66)	0.14
	Environment	2.1 (3.1)	1.4 (2.7)	-0.7 (3.7)	0.02**
	Combined	2.3 (5.1)	1.5 (2.3)	-0.8 (5.4)	0.05**

a= weighted averages used, * indicates significance at the 10% level, ** indicates significance at the 5% level.

6.4.4. Sensitivity analysis

As previously outlined, sensitivity analyses need to be conducted. In this study structural uncertainty around the input health outcome parameters, specifically to test the robustness of the QALYs, is examined. To do so, three one-way sensitivity analysis were conducted which consisted of performing three CEAs using clinical measures (BMI, weight, midway waist circumference) to measure health outcomes. This facilitated an investigation of whether or not the CUA results held across different outcome measures. Furthermore, parameter uncertainty was accounted for through the use of Monte Carlo simulation in the PSA and is outlined in the next section of this chapter.

6.4.5. Probabilistic sensitivity analysis

As the model parameters used in this economic evaluation were estimated from samples themselves, uncertainty may surround their true value (154, 176). In this instance, the aforementioned costs and health outcome parameters were subject to uncertainty. The PSA was performed by firstly, assigning probability distributions to the individual model parameters. As the cost data were non-negative, continuous data they assumed gamma distributions and the outcomes assumed normal probability distributions (176). Secondly A Monte Carlo simulation (10,000 iterations) was employed to propagate uncertainty throughout the model using Microsoft Excel (176). This provided 10,000 different values for expected costs and effects associated with each intervention workplace and the control, reflecting the uncertainty in the model. The average of the expected costs and effects was calculated for each intervention and the control and were used to estimate the ICERs in the probabilistic model. The probabilistic ICERs were then plotted on to an ICE plane. CEACs were used to summarise decision uncertainty.

6.5. Economic evaluation results

This section presents the results of the economic evaluation of the FCW complex workplace dietary interventions. Each of the interventions (education, environment and combined) was compared to the control. This was achieved through firstly conducting a baseline CUA to measure the cost-effectiveness of the interventions in terms of QALYs. Due to the absence of a current explicit national threshold value, this economic evaluation used the most recent Irish threshold value of €45,000/QALY as a benchmark for the ceiling ratio. Secondly, sensitivity analyses were conducted to test the robustness of the QALYs which consisted of performing three CEAs using clinical measures to measure health outcomes (BMI, midway waist circumference and weight). Thirdly, a CBA was employed, whereby the monetary value of absenteeism was employed so as to report the net benefit of the intervention(s) compared to the control, from the employers' perspective.

6.5.1. Cost-effectiveness of education versus control

The cost-effectiveness of the education intervention compared to the control is presented in this section. A baseline CUA which employed QALYs as the outcome measure is presented first (which includes results from the PSA). This is followed by the results of the sensitivity analysis where the three CEA were carried out using clinical health outcome measures (BMI, midway waist circumference and weight). Finally, the results of the CBA, which reported the monetary net benefit of the education intervention compared to the control, are also presented.

6.5.1.1. Baseline analysis: CUA

The results of the CUA of the education intervention compared to the control are included in Table 18. These results were estimated using the cost and utility parameters presented in Tables 16 and 17. To estimate cost-effectiveness, the incremental costs (Δ costs) and incremental QALYs (Δ QALYs) from the education intervention were compared to the control. The results illustrate that the education intervention is more expensive (€37.85) and also more effective (0.039 QALYs) than the control (Table 18). (However, the p-value ($p = 0.333$) indicates that the change in QALYs between the education intervention and the control is not statistically significant). The deterministic ICER is estimated at €971/QALY which means that it costs €971 per employee for an additional QALY. The ICER is below the most recent explicit national cost-effectiveness threshold of €45,000/QALY (159), which indicates that the education intervention can be considered cost-effective when compared to the control.

In order to propagate uncertainty throughout the model, a Monte Carlo simulation was employed in the PSA. The mean costs and QALYs generated from the simulation are also included in Table 18. These PSA results facilitate an investigation of uncertainty around the output parameters. The probabilistic CUA reiterates that the education intervention is more expensive (€37.92) and also more effective than the control (0.035 QALYs). The

PSA ICER (€1,075/QALY) suggests that the education intervention can be considered cost-effective when compared to the control as it falls below €45,000/QALY.

The ICE plane illustrates the uncertainty in the incremental costs and incremental QALYs generated from the PSA results when the education intervention was compared to the control (Figure 7). The red point on the plane represents the average additional costs (€37.92) and the average additional QALYs (0.035 QALYs). This point lies in the North-Eastern quadrant of the ICE plane, indicating that the education intervention is more expensive and more effective than the control. It is evident that no uncertainty surrounds the existence of differences in costs, with the education intervention being more expensive than the control. However, uncertainty exists with regards to the extent of the differences in costs (95^{th} percentile range: €33.29 to €44.76). Meanwhile, uncertainty exists with regards to the presence of differences in QALYs between the education intervention and the control and also with regards to the extent of differences. The extent of this uncertainty is reflected in the 95^{th} percentile range (-0.43 to 0.51 QALYs).

The cost-effectiveness acceptability curve (CEAC) (Figure 8) presents the decision uncertainty surrounding the cost-effectiveness of the education intervention and the control using the PSA results. The probability of the education intervention and the control being cost-effective was plotted against a range of ceiling ratios (€0 to €100,000/QALY). It can be observed from the CEAC, that at a ceiling ratio of €45,000 per QALY, the probability of the control being cost-effective is 98% and the probability of the education intervention being cost-effective is just 2%. As the CEAC demonstrates, at no point between a ceiling ratio of €0 to €100,000 does the education intervention have a higher probability of being cost-effective than the control. Thus, the uncertainty surrounding the incremental costs and the incremental QALYs (Figure 7) does not translate into decision uncertainty. The low probability of the education intervention being cost-effective reflects the additional costs and marginal additional benefits of the education intervention versus the control.

Table 18: Cost-effectiveness of education v's control

Deterministic Results:	Cost (€)	CUA Improvement in QALYs	CEA BMI (kg/m^2)	WC (cm)	Weight (kg)	CBA Absenteeism (days)
Control	33.83	-0.010	+0.36	+1.51	+0.97	+0.34
Education	71.68	+0.029	-0.44	-0.42	-1.22	-0.36
Incremental changes (Δ)	37.85	0.039	-0.80	-1.93	-2.19	-0.69
ICER		*€970.55/QALY*	*€47.04/ kg/m^2*	*€19.57/cm*	*€17.31/kg*	*€54.50/day*
Probabilistic Results:						
Control (average) (95th percentile range)	33.91 (27.04 to 42.31)	-0.008 (-0.38 to 0.37)	+0.38 (-1.98 to 2.74)	+1.45 (-11.69 to 14.73)	+0.98 (-5.67 to 7.68)	+0.36 (-9.45 to 10.48)
Education (average) (95th percentile range)	71.83 (59.27 to 87.10)	0.027 (-0.25 to 0.30)	-0.46 (-3.89 to 2.95)	-0.42 (-9.84 to 8.92)	1.21 (-10.41 to 8.22)	-0.34 (-9.52 to 8.22)
Incremental changes (Δ) (95th percentile range)	37.92 (33.29 to 44.76)	0.035 (-0.43 to 0.51)	-0.84 (-4.99 to 3.37)	-1.87 (-17.96 to 14.15)	-2.18 (-13.54 to 9.29)	-0.70 (-19.20 to 14.93)
ICER		*€1,075.14/QALY*	*€45.04/ kg/m^2*	*€20.28/cm*	*€17.36/kg*	*€53.98/day*
						Net Benefit: €61.84/employee (95% range: €54.90 to €67.82)

Figure 7: Incremental cost-effectiveness plane (QALYs): education v's control

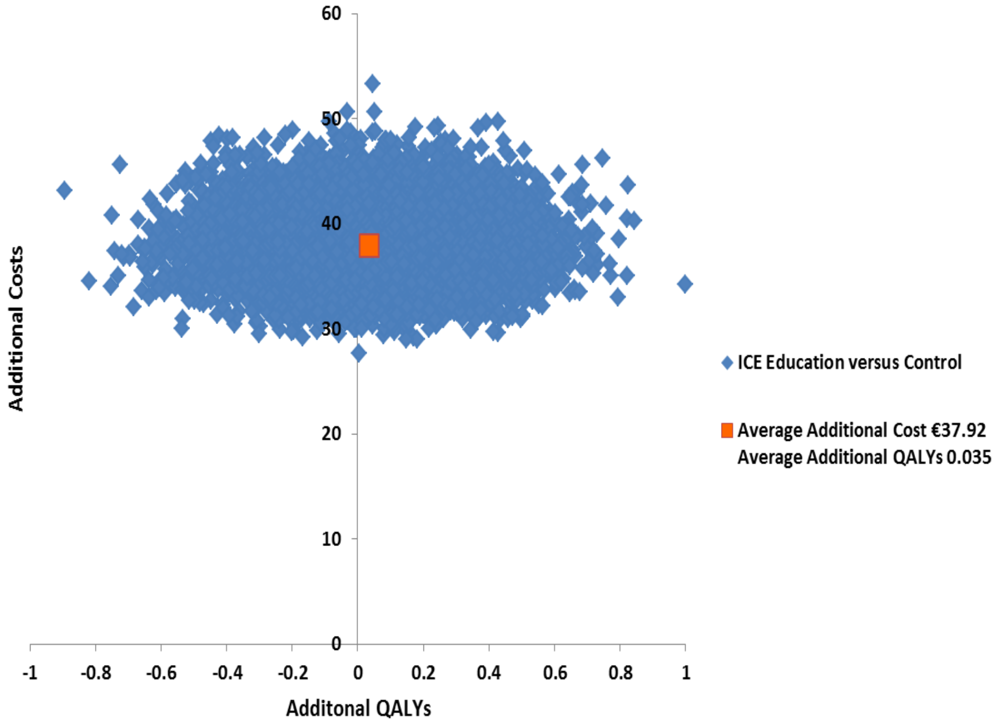
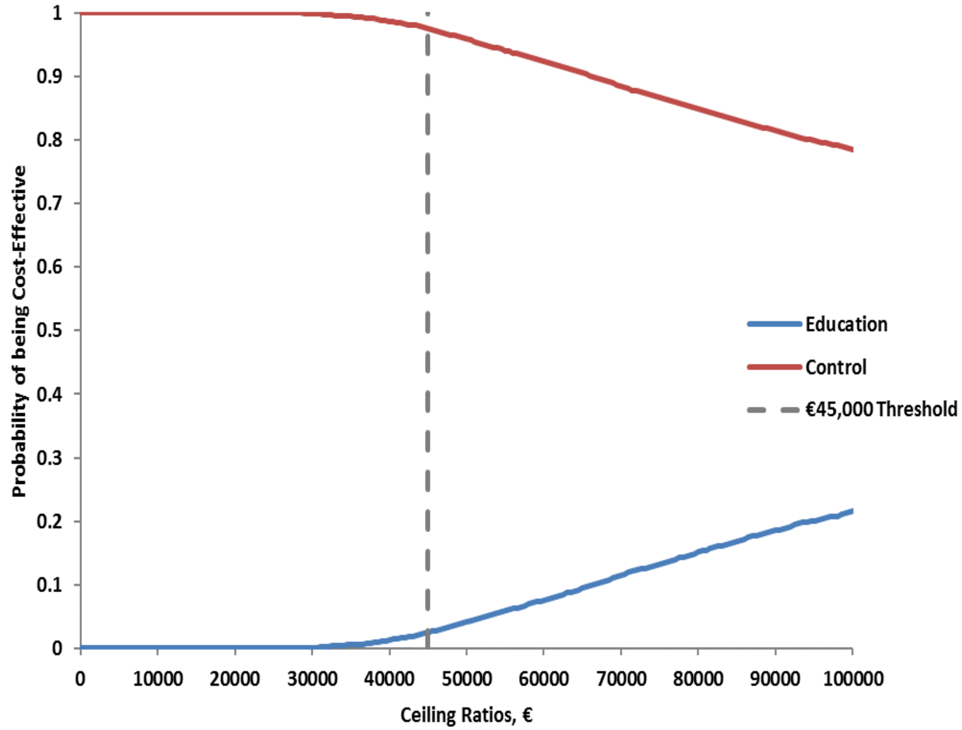


Figure 8: CEAC: education v's control



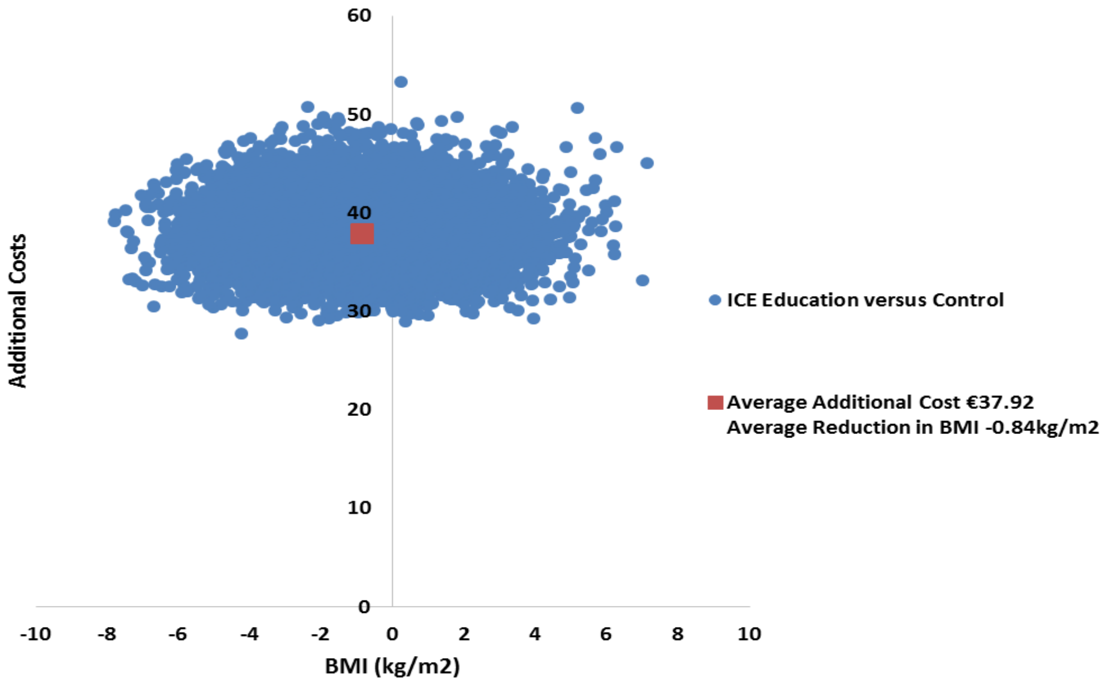
6.5.1.2. Sensitivity analyses: CEA

BMI

This section presents the CEA results using BMI as a health outcome measure. The results on Table 18 indicate that the education intervention is more expensive (€37.85) and more effective at reducing BMI levels (-0.80 kg/m^2) when compared to the control. As the outcome measure is BMI, a reduction is favourable and is considered to be a positive effect. (The p-value of (p = 0.001) suggests that the difference in effects between the education intervention and the control is statistically significant). The deterministic ICER is estimated as €47 per unit (kg/m^2) reduction in BMI, meaning that it costs €47 per employee for a one-unit (kg/m^2) reduction in BMI.

The PSA results confirm the deterministic results that the education intervention is more expensive and more effective than the control in terms of reducing BMI with an ICER of €45 per unit reduction in BMI reported (Table 18). Figure 9 illustrates the uncertainty in the estimates of incremental costs and effects (BMI) when the education intervention was compared to the control. These estimates were generated from the Monte Carlo simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in BMI. This point lies in the North-Western quadrant of the ICE plane, which means that the education intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the education intervention and the control (95th percentile range: €33.29 to €44.76). Uncertainty also exists with regards to the existence of differences in effectiveness between the education intervention and the control and also with regards to the extent of differences. The extent of this uncertainty is reflected in the 95th percentile range (-4.99 to 3.37 kg/m^2).

Figure 9: Incremental cost-effectiveness plane (BMI): education v's control



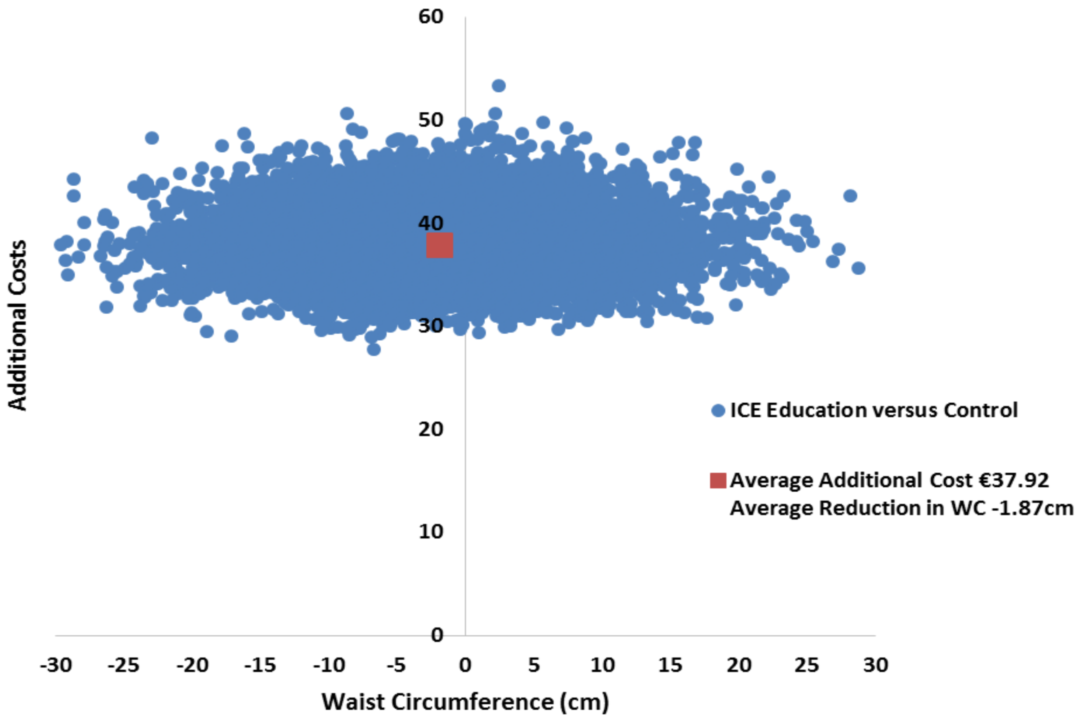
Waist circumference

This section presents the CEA results with a reduction in midway waist circumference (cm) used as the health outcome measure. The results on Table 18 indicate that the education intervention is more expensive (€37.85) and more effective (-1.93 cm) at reducing midway waist circumference when compared to the control. (The p-value of (p = 0.040) suggests that the difference in effects between the education intervention and the control is statistically significant). A reduction in midway waist circumference is favourable and is considered as a positive effect. The deterministic ICER is estimated as €19.57 per unit (cm) reduction in midway waist circumference, meaning that it costs

€19.57 per employee for a one-centimetre (cm) reduction in midway waist circumference.

The PSA results confirm the deterministic results that the education intervention is more expensive and more effective than the control in terms of reducing midway waist circumference with an ICER of €20.28 per unit (cm) reduction in midway waist circumference reported (Table 18). Figure 10 illustrates the uncertainty in the estimates of incremental costs and effects (midway waist circumference) when the education intervention was compared to the control. These estimates were generated from the Monte Carlo simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in midway waist circumference. This point lies in the North-Western quadrant of the ICE plane, meaning the education intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the education intervention and the control (95th percentile range: €33.29 to €44.76). Uncertainty also surrounds the existence of differences in effectiveness between the education intervention and the control and also with regards to the extent of differences. The extent of this uncertainty is reflected in the 95th percentile range (-17.96 to 14.15 cm).

Figure 10: Incremental cost-effectiveness plane (waist circumference): education v's control



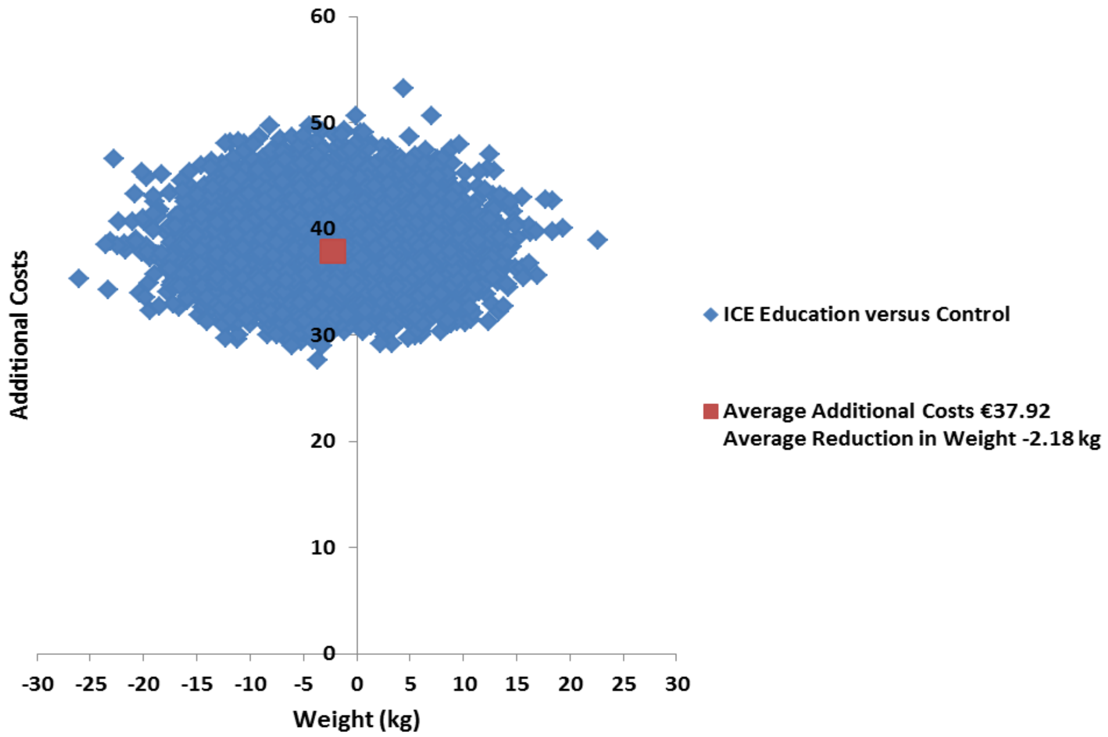
Weight

This section presents the CEA results with a reduction in body weight (kg) used as the health outcome measure. The results on Table 18 indicate that the education intervention is more expensive (€37.85) and more effective (-2.19 kg) at reducing weight when compared to the control. (The p-value (p = 0.001) suggests that the different in effects may be statistically significant.) A reduction in weight is considered to be a positive effect. The deterministic ICER is estimated as €17 per unit (kg) reduction in weight, which means that it costs €17 per employee for a reduction of 1kg in weight.

The PSA results confirm the deterministic results that the education intervention is more expensive and more effective than the control in terms of reducing body weight with an

ICER of €17 per unit reduction in weight reported (Table 18). Figure 11 illustrates the uncertainty in the estimates of incremental costs and effects when the education intervention was compared to the control. These estimates were generated from the Monte Carlo simulation as part of the PSA. The red point on the plane represents the average additional costs and the average additional reductions in weight. The point lies in the North-Western quadrant of the ICE plane, demonstrating that the education intervention is more expensive and more effective than the control. As was seen in the CUA, there was uncertainty surrounding the extent of the differences in costs between the education intervention and the control (95^{th} percentile range: €33.29 to €44.76). Uncertainty also surrounds the existence of differences in effectiveness between the education intervention and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95^{th} percentile range: (-13.54 to 9.29 kg).

Figure 11: Incremental cost-effectiveness plane (weight): education v's control

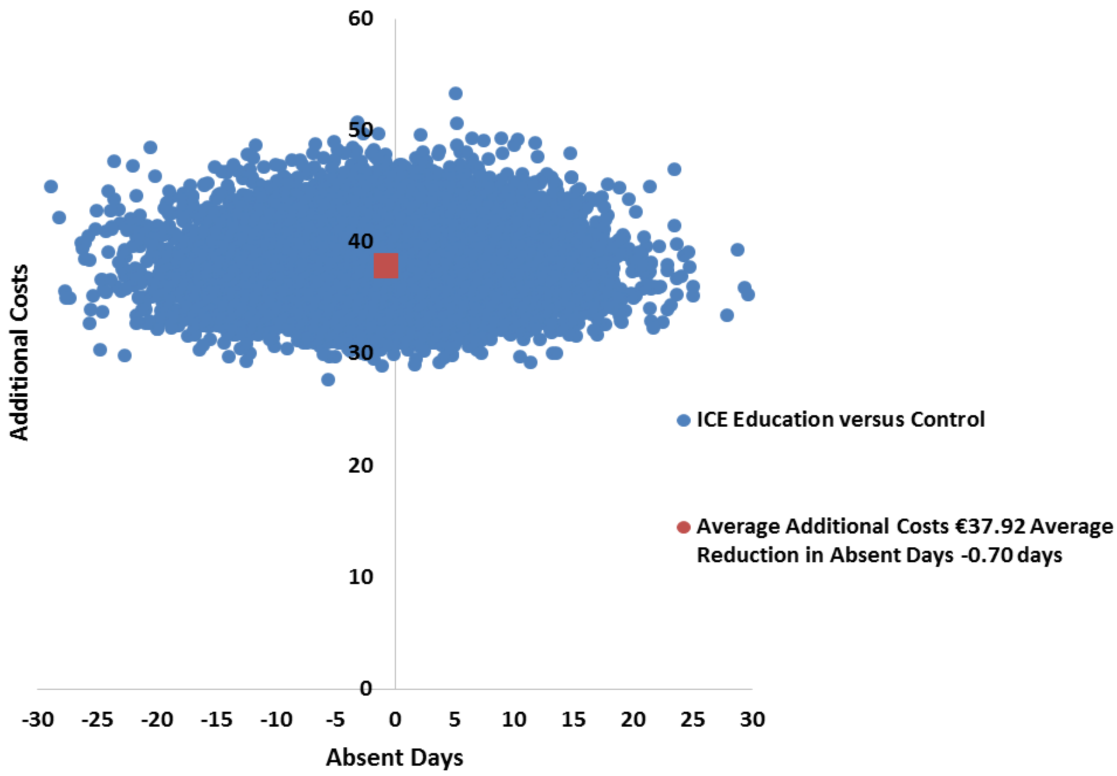


6.5.1.3. CBA

The cost parameters and absenteeism parameters presented in Tables 16 and 17 of this thesis were employed to conduct a CBA, whereby, a monetary value was placed on absenteeism to estimate net benefit (Table 18). The results indicate that the education intervention is more expensive (€37.85) and more effective (-0.69 days) at reducing absenteeism than the control. The p-value (p = 0.270) suggests that the difference in effects may not be statistically significant. The deterministic ICER is estimated at €55 per absent day avoided, which means that it costs €55 per employee for a reduction of one absent day.

The PSA results confirm the deterministic results that the education intervention is more expensive and more effective than the control in terms of reducing absenteeism with an ICER of €54 per absent day avoided reported (Table 18). Figure 12 illustrates the uncertainty in the estimates of incremental costs and effects when the education intervention was compared to the control. These estimates were generated from the Monte Carlo simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in absenteeism. This point lies in the North-Western quadrant of the ICE plane, demonstrating that the education intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the education intervention and the control (95th percentile range: €33.29 to €44.76). Uncertainty also surrounds the existence of differences in effectiveness between the education intervention and the control and also with regards to the extent of differences. The extent of this uncertainty is reflected in the 95th percentile range (-19.20 to 14.93 absent days).

Figure 12: Incremental cost-effectiveness plane (absenteeism): education v's control



<u>Net benefit</u>

Using IBEC's estimate (51) of the daily cost of absenteeism per employee (€144.48) as the ceiling ratio, the net benefit of the education intervention compared to the control was estimated. Recalling the equation for calculating net benefit (equation 2):

$$(\textit{Ceiling ratio} * \Delta E) - \Delta C > 0$$

Substituting IBEC's estimate (€144.48) for the ceiling ratio, 0.69 as the incremental benefits (absenteeism reduction) and €37.85 as the incremental costs, the net benefit of the education intervention compared to the control was calculated as follows:

(€144.48* 0.69) - €37.85 = €61.84

A positive net benefit per employee of €61.84 indicates that the benefits (a reduction of 0.69 days absent) exceed the cost of the education intervention (€37.85) compared to the control. Therefore, from the employers' perspective, the education intervention can be considered cost-effective. The PSA results confirm the CBA results with an estimated positive net benefit per employee of €62.05 generated from the Monte Carlo simulation in the PSA. The 95th percentile range (€54.90- €67.82) reflects the uncertainty in the net benefit estimated from the PSA.

6.5.2. Cost-effectiveness of environment versus control

Next, the cost-effectiveness of the environment intervention compared to the control is presented. As before, the same approach is adopted with a baseline CUA which employed QALYs as the outcome measure presented first (which includes results from the PSA). This is followed by the results of the sensitivity analysis where three CEA were carried out using clinical health outcome measures (BMI, midway waist circumference and weight). Finally, the results of the CBA, which reported the monetary net benefit of the education intervention compared to the control, are also presented.

6.5.2.1 Baseline analysis: CUA

The results of the CUA of the environment intervention compared to the control are included on Table 19. These results were estimated using the cost and utility parameters presented in Tables 16 and 17. To estimate cost-effectiveness, the incremental costs (Δ costs) and incremental QALYs (Δ QALYs) from the environment intervention were compared to the control. The results illustrate that the environment intervention is marginally more expensive (€5.88) and more effective (0.060 QALYs) than the control (Table 19). (However, the p-value ($p = 0.456$) indicates that the change in QALYs between the environment intervention and the control is not statistically significant). The deterministic ICER is estimated as €98/QALY which means that it costs €98 per employee for an additional QALY. The ICER is below the most recent explicit national cost-effectiveness threshold of €45,000/QALY (159), indicating that the environment intervention can be considered cost-effective when compared to the control.

Uncertainty was propagated through the model by the employment of the Monte Carlo simulation in the PSA. The mean costs and QALYs generated from the simulation are also included in Table 19. These PSA results facilitate an investigation of uncertainty around the output parameters. The probabilistic CUA reiterates that the education intervention is more expensive (€5.90) and more effective than the control (0.063 QALYs). The PSA ICER (€92.96/QALY) also suggests that the environment intervention can be considered cost-effective when compared to the control as it falls below €45,000/QALY.

The ICE plane (Figure 13) illustrates the uncertainty in the incremental costs and incremental QALYs generated from the PSA when the environment intervention was compared to the control. The red point on the plane represents the average additional costs (€5.90) and the average additional QALYs (0.063 QALYs). This point lies in the North-Eastern quadrant of the ICE plane, indicating that the environment intervention is more expensive and more effective than the control. No uncertainty surrounds the existence of differences in costs, with the environment intervention being more expensive than the control. However, there is uncertainty with regards to the extent of the cost differences (95th percentile range: €4.29 to €7.84). Meanwhile, uncertainty also surrounds the presence and extent (95th percentile range: -0.47 to 0.60 QALYs) of differences in QALYs between the environment intervention and the control.

The CEAC (Figure 14) presents the decision uncertainty surrounding the cost-effectiveness of the environment intervention and the control. The probability of the environment intervention and the control workplace being cost- effective was plotted against a range of ceiling ratios (€0 to €100,000). It can be observed that at a ceiling ratio of €45,000/QALY, both the environment intervention and the control have a 50% probability of being cost-effective. Therefore, the uncertainty surrounding the incremental costs and the incremental QALYs does translate into decision uncertainty. It can be observed that as the ceiling ratios increase beyond €45,000, the probability of the environment intervention being cost-effective increases and falls for the control. This may be due to the fact that the environment had only marginally higher costs than the control workplace and the additional benefits reported in the control were also low.

Table 19: Cost-effectiveness of environment v's control

	Cost	CUA	Secondary CEA			CBA
Deterministic Results:	**€**	**Improvement in QALYs**	**BMI (kg/m^2)**	**WC (cm)**	**Weight (kg)**	**Absenteeism (days)**
Control	33.83	-0.010	+0.36	+1.51	+0.97	+0.34
Environment	39.70	+0.050	-0.05	-0.47	-0.10	-0.71
Incremental changes (Δ)	5.88	0.060	-0.41	-1.98	-0.87	-1.05
ICER		€97.95/QALY	*€14.22 /kg/m^2*	*€2.97/cm*	*€6.73/kg*	*€5.60/day*
Probabilistic Results:						
Control (95th percentile range)	33.91 (27.04 to 42.31)	-0.008 (-0.38 to 0.37)	+0.38 (-1.98 to 2.74)	+1.45 (-11.69 to 14.73)	+0.98 (-5.67 to 7.68)	+0.36 (-9.45 to 10.48)
Environment (95th percentile range)	39.80 (31.32 to 50.17)	0.055 (-0.34 to 0.45)	-0.04 (-2.08 to 2.20)	-0.43 (-5.67 to 5.28)	+0.13 (-5.36 to 5.75)	-0.76 (-8.06 to 6.00)
Incremental changes (Δ) (95th percentile range)	5.90 (4.29 to 7.84)	0.063 (-0.47 to 0.60)	-0.42 (-3.57 to 2.84)	-1.89 (-15.26 to 11.75)	-0.85 (-9.65 – 7.48)	-1.12 (-15.32 – 13.40)
ICER		*€92.96/QALY*	*€14.04 /kg/m^2*	*€3.13/cm*	*€6.96/kg*	*€5.27/day*
						Net benefit*:* €145.82/employee (95% range: €143.61 to €147.30)

Figure 13: Incremental cost-effectiveness plane (QALYs): environment v's control

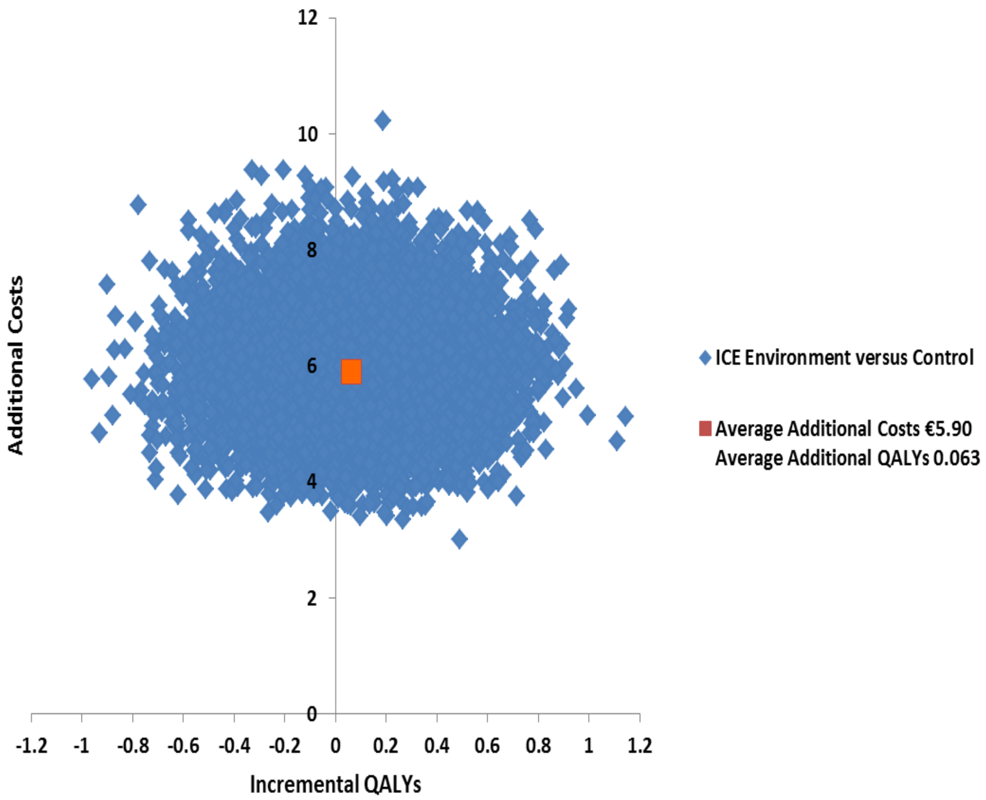
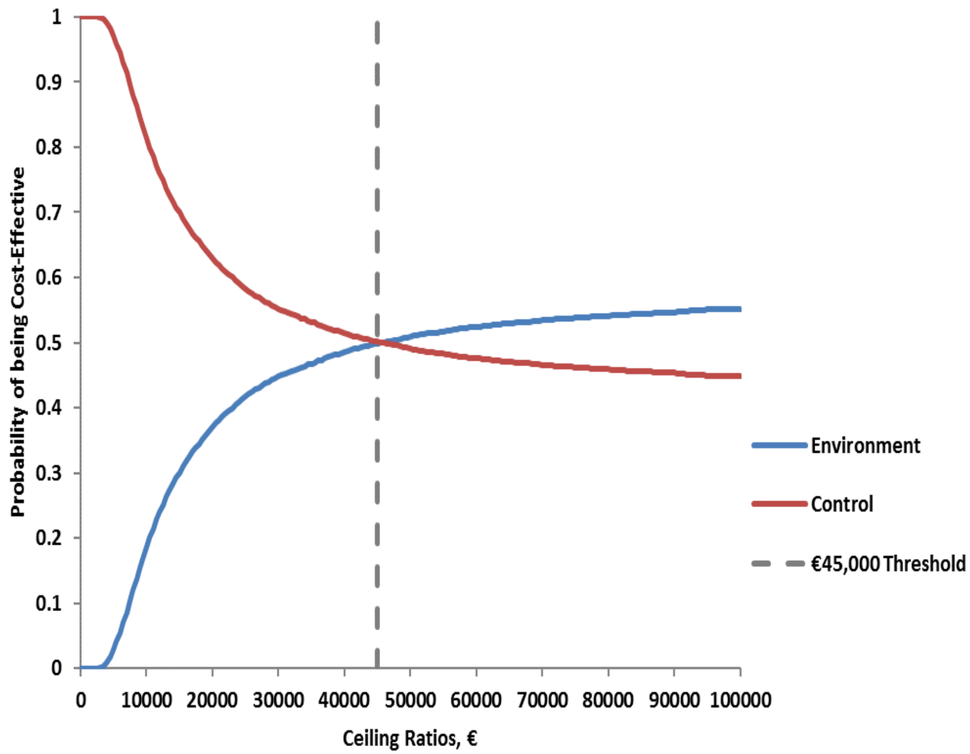


Figure 14: CEAC environment v's control



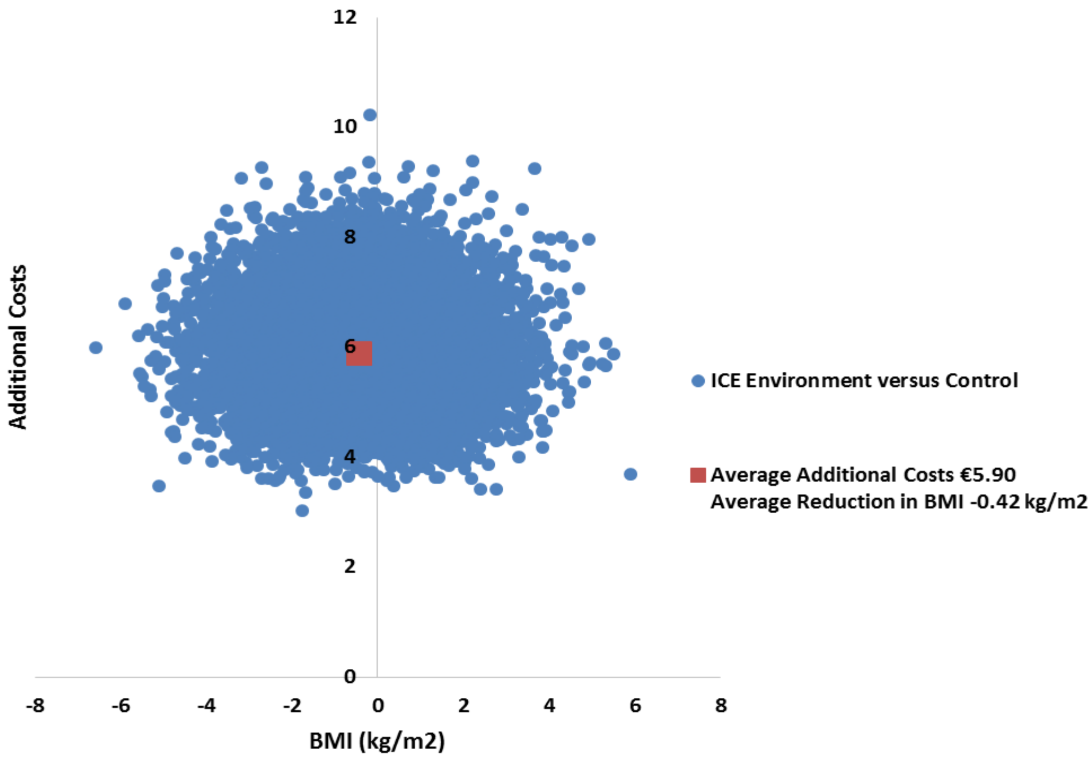
6.5.2.2. Sensitivity analyses: CEA

BMI

This section presents the CEA results using BMI as a health outcome measure. The results on Table 19 indicate that the environment intervention is more expensive (€5.88) and more effective at reducing BMI levels (-0.41 kg/m^2) when compared to the control. As the outcome measure is BMI, a reduction is favourable and is considered to be a positive effect. (The p-value of (p = 0.031) suggests that the difference in effects between the environment intervention and the control is statistically significant). The deterministic ICER is estimated at €14.22 per unit (kg/m^2) reduction in BMI, meaning that it costs €14 per employee for a one-unit (kg/m^2) reduction in BMI.

The PSA results confirm the deterministic results that the environment intervention is more expensive and more effective than the control in terms of reducing BMI with an ICER of €14 per unit reduction in BMI reported (Table 19). Figure 15 illustrates the uncertainty in the estimates of incremental costs and effects (BMI) when the environment intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in BMI. This point lies in the North-Western quadrant of the transposed ICE plane, demonstrating that the environment intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the environment intervention and the control (95th percentile range: €4.29 to €7.84). Uncertainty also exists with regards to the existence of differences effectiveness between the environment education and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95th percentile range (-3.57 to 2.84 kg/m^2).

Figure 15: Incremental cost-effectiveness plane (BMI): environment v's control

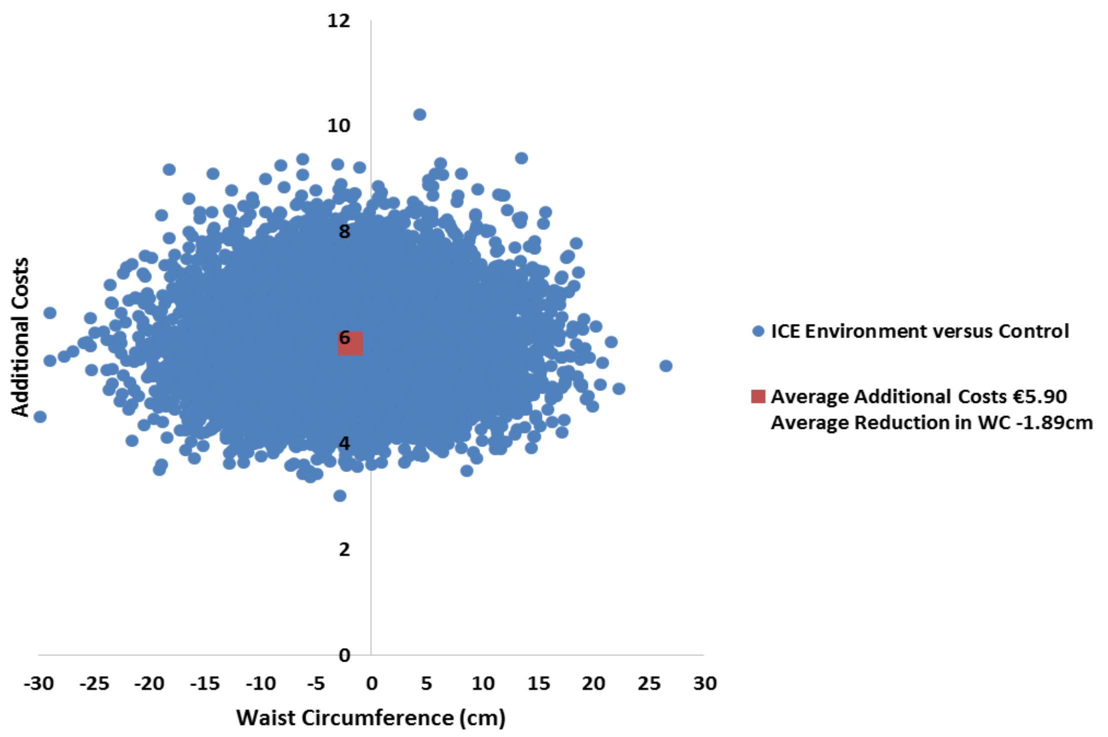


Waist circumference

This section presents the CEA results with a reduction in midway waist circumference (cm) used as the health outcome measure. The results on Table 19 indicate that the environment intervention is more expensive (€5.88) and more effective (-1.98 cm) at reducing midway waist circumference when compared to the control. (The p-value of ($p = 0.026$) suggests that the difference in effects between the environment intervention and the control is statistically significant). A reduction in midway waist circumference is favourable and is considered as a positive effect. The deterministic ICER is estimated as €3 per unit (cm) reduction in midway waist circumference, meaning that it costs €3 per employee for a one-centimetre (cm) reduction in waist circumference.

The PSA results also confirm the deterministic results that the environment intervention is more expensive and more effective than the control in terms of reducing midway waist circumference with an ICER of €3 per unit (cm) reduction in midway waist circumference reported (Table 19). Figure 16 illustrates the uncertainty in the estimates of incremental costs and effects (midway waist circumference) when the environment intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in midway waist circumference. This point lies in the North-Western quadrant of this ICE plane, meaning that the environment intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the environment intervention and the control (95^{th} percentile range: €4.29 to €7.84). Uncertainty also surrounds the existence of differences in effectiveness between the environment intervention and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95^{th} percentile range (-9.65 to 7.48 cm).

Figure 16: Incremental cost-effectiveness plane (waist circumference): environment v's control

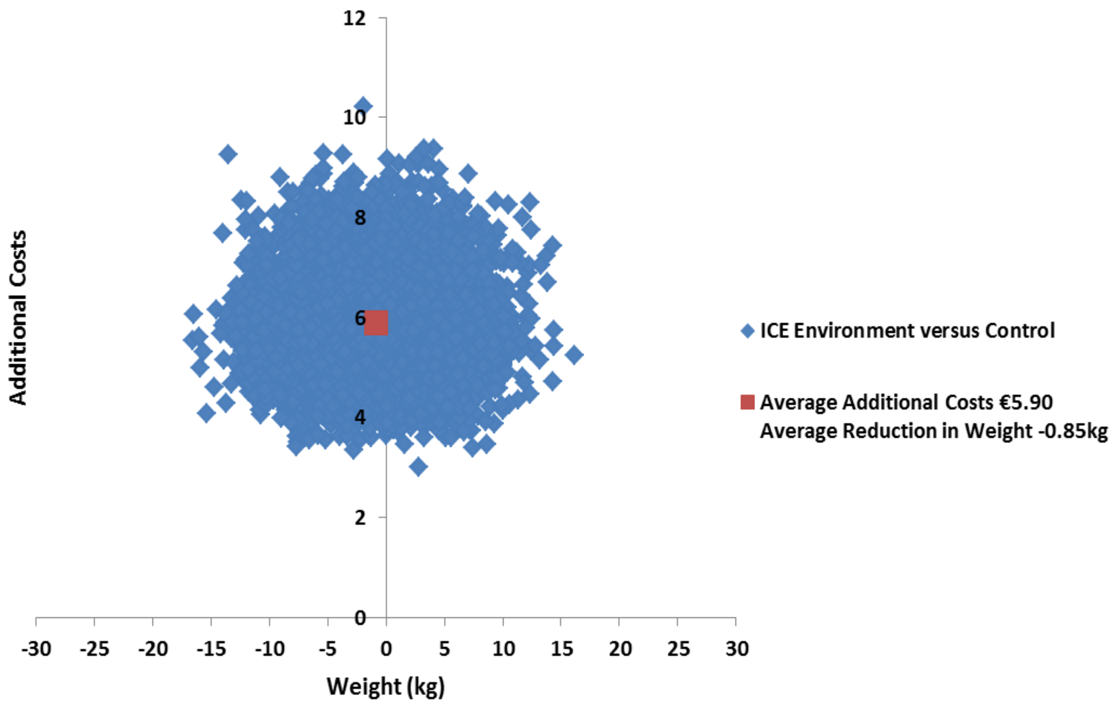


<u>Weight</u>

This section presents the CEA results with a reduction in body weight (kg) used as the health outcome measure. The results on Table 19 indicate that the environment intervention is more expensive (€5.88) and more effective (-0.87 kg) at reducing weight when compared to the control. (However, the p-value (p = 0.105) suggests that the difference in effects may not be statistically significant). A reduction in weight is considered to be a positive effect. The deterministic ICER is estimated as €7 per unit (kg) reduction in weight, which means that it costs €7 per employee for a reduction of 1kg in weight.

The PSA results confirm the deterministic results that the environment intervention is more expensive and effective than the control in terms of reducing body weight with an ICER of €7 per unit reduction in weight reported (Table 19). Figure 17 illustrates the uncertainty in the estimates of incremental costs and effects when the environment intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in weight. This point lies in the North-Western quadrant of the ICE plane, demonstrating that the environment intervention is more expensive and more effective than the control. As was seen in the CUA, there is uncertainty surrounding the extent of the differences in costs between the environment intervention and the control (95^{th} percentile range: €4.29 to €7.84). Uncertainty also surrounds the existence of differences in effectiveness between the environment intervention and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95^{th} percentile range (-9.65 to 7.48 kg).

Figure 17: Incremental cost-effectiveness plane (weight): environment v's control

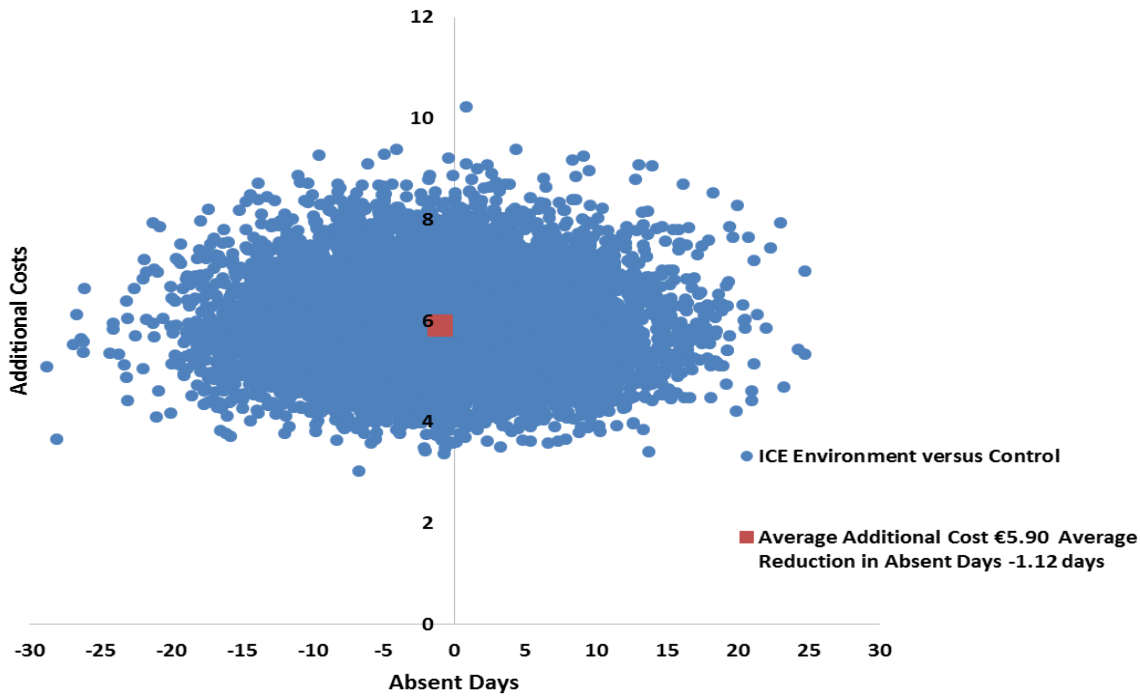


6.5.2.3. CBA

Just as before, the cost parameters and absenteeism parameters that were presented in sections 6.3.3 and 6.3.4 of this chapter were employed to conduct a CBA, whereby a monetary value was places on absenteeism to estimate net benefit (Table 19). The results indicate that the environment intervention is more expensive (€5.88) and more effective (-1.05 days) at reducing absenteeism when compared to the control. The p-value ($p = 0.640$) suggests that the difference in effects may not be statistically significant. The deterministic ICER is estimated at €6 per absent day avoided, which means that it costs €6 per employee for a reduction of one absent day.

The PSA results confirm the deterministic results that the environment intervention is more expensive and more effective than the control in terms of reducing absenteeism with an ICER of €5 per absent day avoided reported (Table 19). Figure 18 illustrates the uncertainty in the estimates of incremental costs and effects (absent days) when the environment intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in absent days. This point lies in the North-Western quadrant of the transposed ICE plane. As a reduction in absent days is considered positive, the ICE demonstrates that the environment intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the environment intervention and the control (95th percentile range: €4.29 to €7.84). Uncertainty also surrounds the existence of differences in effectiveness between the environment intervention and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95th percentile range (-15.32 to 13.40 days).

Figure 18: Incremental cost-effectiveness plane (absenteeism): environment v's control



<u>Net benefit</u>

Using IBEC's estimate (51) of the daily cost of absenteeism per employee (€144.48) as the ceiling ratio, the net benefit of the environment intervention compared to the control was estimated. Recalling the equation for calculating net benefit (equation 2):

$$(\text{Ceiling ratio}^{*}\ \Delta E) - \Delta C > 0$$

Substituting IBEC's estimate (€144.48) for the ceiling ratio, a reduction of 1.05 days as the incremental benefits and €5.88 as the incremental costs, the net benefit of the environment intervention compared to the control was calculated as follows:

(€144.48* 1.05) - €5.88 = €145.82

A positive net benefit per employee of €145.82 indicates that the benefits (a reduction of 1.05 days absent) exceed the cost of the intervention (€5.88) compared to the control. Therefore, from the employers' perspective, the environment intervention can be considered cost-effective. The PSA results confirm the CBA results with an estimated positive net benefit per employee of €141.60 generated from the Monte Carlo simulation in the PSA. The 95th percentile range (€143.61 to €147.30) reflects the uncertainty in the net benefit estimated from the PSA.

6.5.3. Cost-effectiveness of combined versus control

The cost-effectiveness of the combined intervention compared to the control workplace is presented in the following section. A baseline CUA which employed QALYs as the outcome measure is presented first (which includes results from the PSA). This is followed by the results of the sensitivity analysis where the three CEA were carried out using clinical health outcome measures (BMI, midway waist circumference and weight). Finally, the results of the CBA, which reported the monetary net benefit of the combined intervention compared to the control, are also presented.

6.5.3.1. Baseline analysis: CUA

The results of the CUA of the combined intervention compared to the control are included in Table 20. These results were estimated using the cost and utility parameters presented in Tables 16 and 17. To estimate cost-effectiveness, the incremental costs (Δ costs) and incremental QALYs (Δ QALYs) from the combined intervention were compared to the control. The results indicate that the combined intervention is more expensive (€43.12) and more effective (0.020 QALYs) than the control (Table 20). (However, the p-value of ($p = 0.718$) indicates that the change in QALYs between the combined intervention and the control is not statistically significant). The deterministic ICER is estimated at €2,156/QALY, which means that it costs €2,156 per employee for an additional QALY. The ICER is below the most recent explicit national cost-effectiveness threshold of €45,000/QALY (159), indicating that the combined intervention is cost-effective compared to the control.

Uncertainty was propagated through the model by the employment of the Monte Carlo simulation in the PSA. The mean costs and QALYs generated from the simulation are also included in Table 20. These PSA results facilitate an investigation of uncertainty around the output parameters. The probabilistic CUA reiterates that the combined intervention is more expensive (€43.20) and more effective than the control (0.016 QALYs). The PSA ICER (€2,687/QALY) also suggests that the combined intervention can be considered cost-effective when compared to the control as it falls below €45,000/QALY.

The ICE) plane (Figure 19) illustrates the uncertainty in the incremental costs and incremental QALYs generated from the PSA when the combined intervention was compared to the control. The red point on the plane represents the average additional costs (€43.20) and the average additional QALYs (0.016 QALYs). This point lies in the North-Eastern quadrant of the ICE plane, indicating that the combined intervention is more expensive and more effective than the control. No uncertainty surrounds the existence of differences in costs with the combined intervention being more expensive than the control. However, there is uncertainty with regards to the extent of the cost differences (95th percentile range: €36.17 to €51.77). Meanwhile, uncertainty also exists with regards to the presence of differences in QALYs between the combined intervention and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95th percentile range (-0.46 to 0.48 QALYs).

The CEAC (Figure 20) presents the decision uncertainty surrounding the cost-effectiveness of the combined intervention and the control. The probability of the combined intervention and the control workplace being cost-effective was plotted against a range of ceiling ratios (€0 - €100,000/QALY). It can be observed that at a ceiling ratio of €45,000 per QALY, the control has a 99% probability of being cost-effective, while the combined intervention has just a 1% probability. As the CEAC demonstrates, at no point between a ceiling ratio of €0 to €100,000 does the combined intervention have a higher probability of being cost-effective than the control. Thus, the uncertainty surrounding the incremental costs and incremental QALYs does not translate into decision uncertainty. The low probability of the combined intervention being cost-effective reflects the additional costs and marginal additional benefits of the combined intervention versus the control.

Table 20: Cost-effectiveness of combined v's control

Deterministic Results:	**Cost**	**CUA**	**Secondary Analyses**			**CBA**
	(€)	**Improvement in QALYs**	**BMI (kg/m^2)**	**WC (cm)**	**Weight (kg)**	**Absenteeism (days)**
Control	33.83	-0.010	+0.36	+1.51	+0.97	+0.34
Combined	76.95	0.010	-0.07	-0.43	-0.18	-0.78
Incremental changes (Δ)	43.12	0.020	-0.43	-1.94	1.15	-1.12
ICER		*€2,156.05/QALY*	*€99.77 /kg/m^2*	*€22.23/cm*	*€37.54/kg*	*€38.55/day*
Probabilistic Results:						
Control (95th percentile range)	33.91 (27.04 to 42.31)	-0.008 (-0.38 to 0.37)	+0.38 (-1.98 to 2.74)	+1.45 (-11.69 to 14.73)	+0.98 (-5.67 to 7.68)	+0.36 (-9.45 to 10.48)
Combined (95th percentile range)	77.11 (63.14 to 94.08)	0.008 (-0.27 to 0.29)	-0.06 (-2.00 – 1.91)	-0.51 (-7.81 to 6.55)	-0.14 (-5.18 to 4.83)	-0.79 (-11.57 to 9.54)
Incremental changes (Δ) (95th percentile range)	43.20 (36.17 to 51.77)	0.016 (-0.46 to 0.48)	-0.44 (-3.62 to 2.54)	-1.96 (-13.75 to 16.82)	-1.11 (-9.29 to 7.01)	-1.15 (-13.90 to 14.90)
ICER		*€2,686.61/QALY*	*€98.04 /kg/m^2*	*€22.03/cm*	*€38.78/kg*	*€37.66/day*
						Net benefit: €118.70/employee (95th range: €105.45 to €121.51)

Figure 19: Incremental cost-effectiveness plane (QALYs): combined v's control

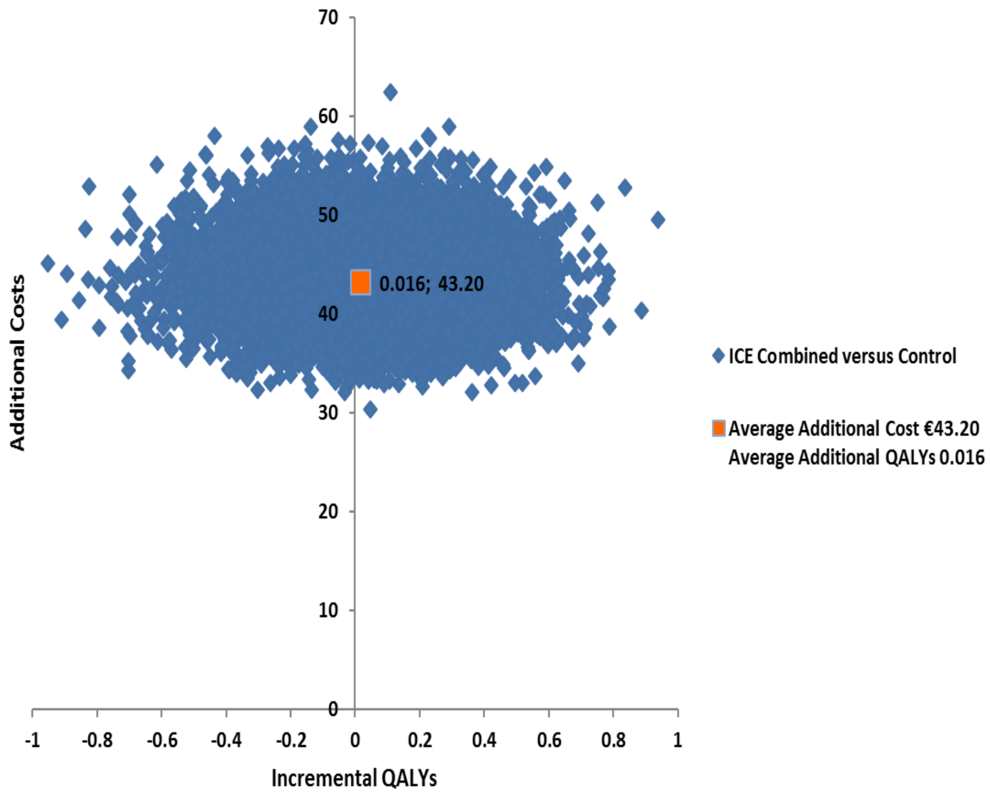
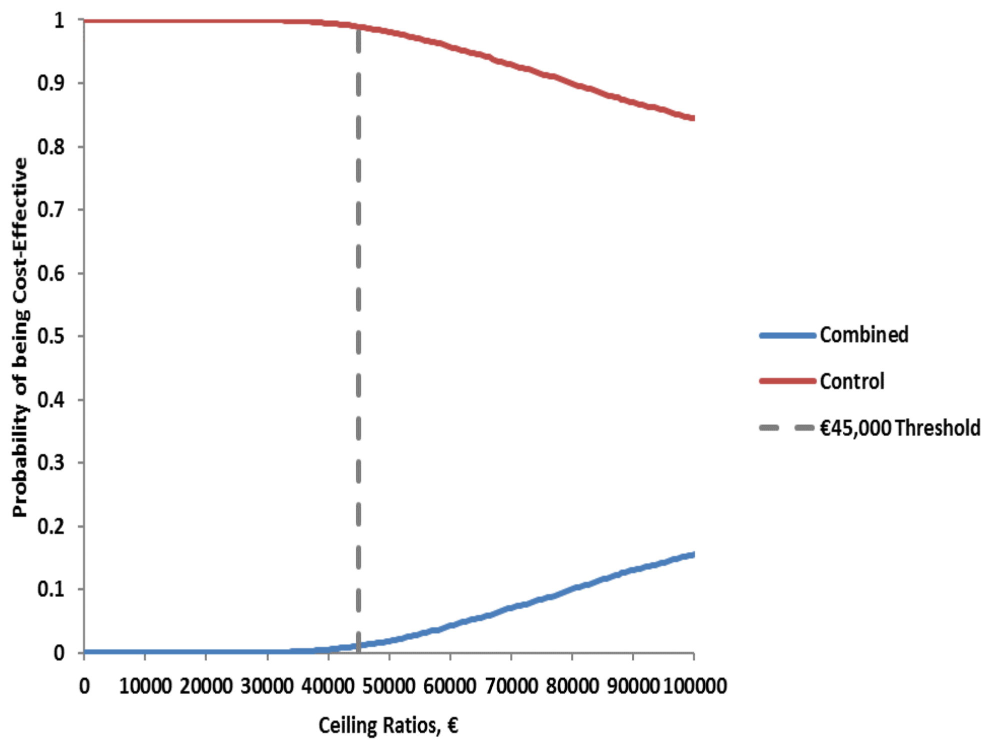


Figure 20: CEAC combined v's control



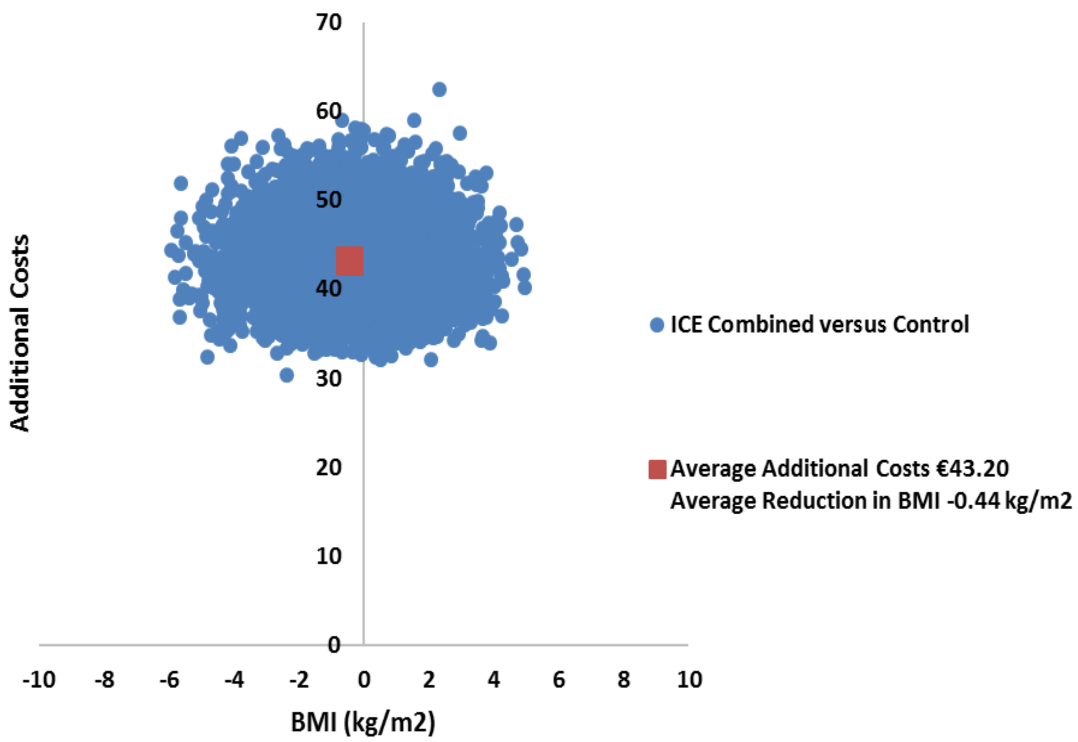
6.5.3.2. Sensitivity analyses: CEA

BMI

This section presents the CEA results with a reduction in BMI as a health outcome measure. The results on Table 20 indicate that the combined intervention is more expensive (€43.12) and more effective (-0.43 kg/m^2) at reducing BMI levels when compared to the control. As the outcome measure is BMI, a reduction is favourable and is considered to be a positive effect. (However, the p-value ($p = 0.064$) suggests that the difference in effects between the combined intervention and the control is not statistically significant). The deterministic ICER is estimated as €100 per unit (kg/m^2) reduction in BMI, meaning that it costs €100 per employee for a one-unit reduction (kg/m^2) in BMI.

The PSA results confirm the deterministic results that the combined intervention is more expensive and effective that the control in terms of reducing BMI with an ICER of €98 per unit reduction in BMI reported (Table 20). Figure 21 illustrates the uncertainty in the estimates of incremental costs and effects (BMI) when the combined intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in BMI. This point lies in the North-Western quadrant of the ICE plane and demonstrates that the combined intervention is more expensive and more effective than the control. As was seen in the CUA, there is uncertainty surrounding the extent of the differences in costs between the combined intervention and the control (95th percentile range: €36.17 to €51.77). Uncertainty also exists with regards to the existence of differences in effectiveness between the combined intervention and the control and also with regards to the extent of differences. The extent of this uncertainty is reflected in the 95th percentile range (-3.62 to 2.54 kg/m^2).

Figure 21: Incremental cost-effectiveness plane (BMI): combined v's control

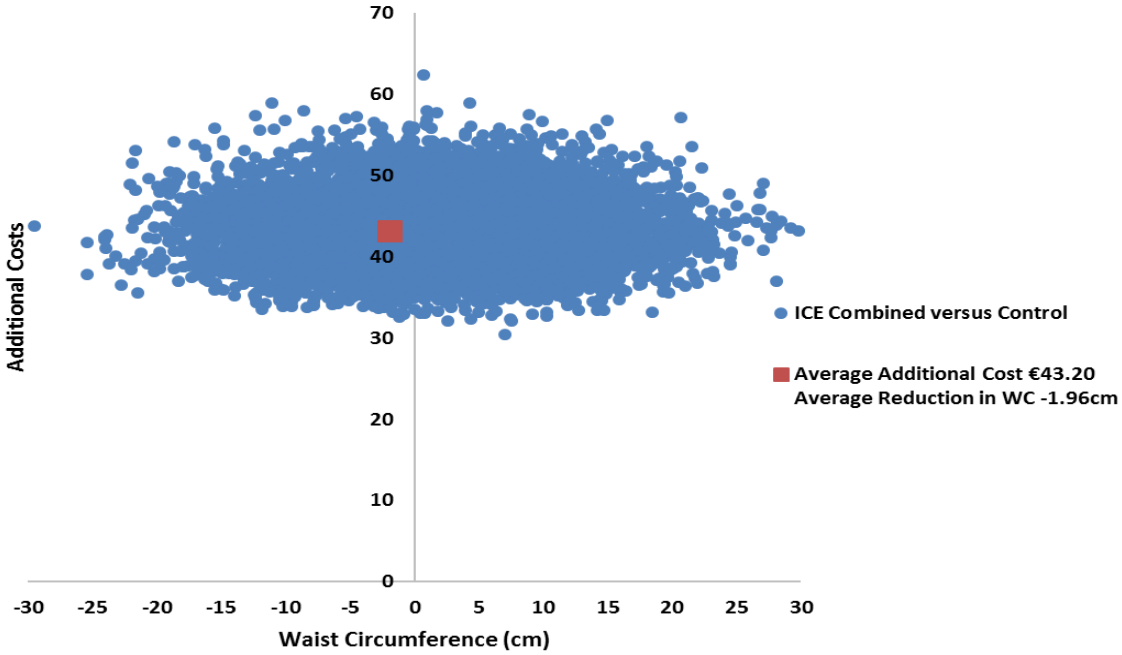


Waist circumference

This section presents the CEA results with a reduction in midway waist circumference (cm) used as the health outcome measure. The results on Table 20 indicate that the combined intervention is more expensive (€43.20) and more effective (-1.94cm) at reducing midway waist circumference when compared to the control. (The p-value of (p = 0.024) suggests that the difference in effects between the combined intervention and the control is statistically significant). A reduction in midway waist circumference is favourable and is considered to be a positive effect. The deterministic ICER is estimated as €22 per unit (cm) reduction in midway waist circumference, meaning that it costs €22 per employee for a one-centimetre (cm) reduction in midway waist circumference.

The PSA results also indicate that the combined intervention is more expensive and more effective than the control in terms of reducing midway waist circumference with an ICER of €22 per unit (cm) reduction in midway waist circumference reported (Table 20). Figure 22 illustrates the uncertainty in the estimates of incremental costs and effects (midway waist circumference) when the combined intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in midway waist circumference. This point lies in the North-Western quadrant of the ICE plane. As a reduction in midway waist circumference is considered positive, the ICE demonstrates that the combined intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the combined intervention and the control (95th percentile range: €36.17 to €51.77). Uncertainty also surrounds the existence of differences between the combined intervention and the control and also with regards to the extent of differences. The extent of this uncertainty is reflected in the 95th percentile range (-13.75 to 16.82 cm).

Figure 22: Incremental cost-effectiveness plane (waist circumference): combined v's control

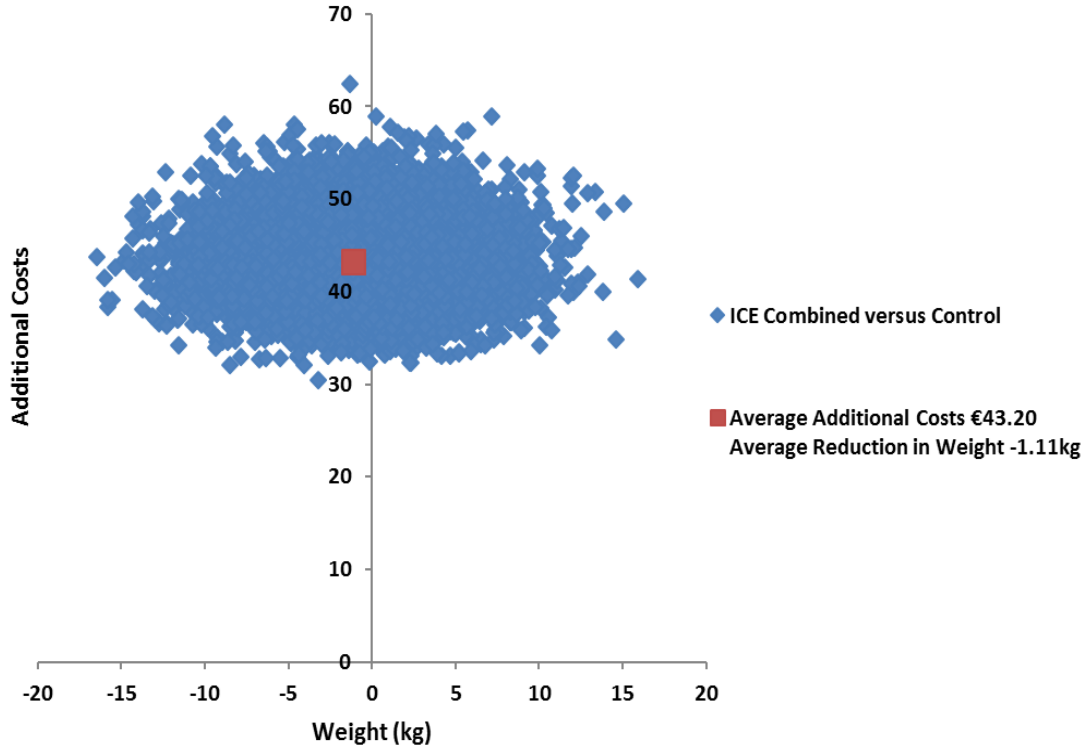


Weight

This section presents the CEA results with a reduction in body weight (kg) used as the health outcome measure. The results on Table 20 indicate that the combined intervention is more expensive (€43.12) and more effective (-1.15 kg) at reducing weight when compared to the control. (However, the p-value of (p = 0.280) suggests that the difference in effects is not statistically significant). A reduction in weight is considered to be a positive effect. The deterministic ICER was estimated as €38 per unit (kg) reduction in weight, which means that it costs €38 per employee for a reduction of 1kg in weight.

The PSA results confirm the deterministic results that the combined intervention is more expensive and more effective than the control in terms of reducing body weight with an ICER of €39 per unit reduction in weight reported (Table 20). Figure 23 illustrates the uncertainty in the estimates of incremental costs and effects (weight) when the combined intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average additional reductions in weight. This point lies in the North-Western quadrant of the ICE plane, demonstrating that the combined intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the combined intervention and the control (95th percentile range: €36.17 to €51.77). Uncertainty also surrounds the existence of differences in effectiveness between the education intervention and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95th percentile range (-9.29 to 7.01 kg).

Figure 23: Incremental cost-effectiveness plane (weight): combined v's control

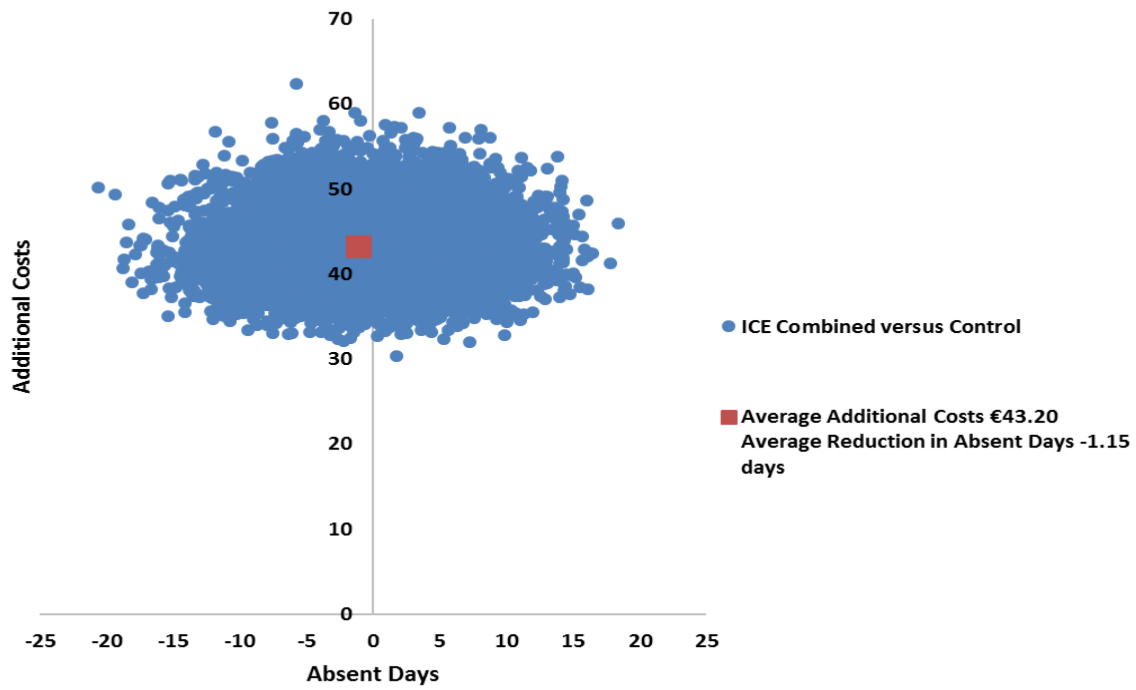


6.5.3.3. CBA

The cost parameters and absenteeism parameters presented in sections 6.3.3 and 6.3.4 of this chapter were employed to conduct a CBA, whereby, a monetary value was placed on absenteeism to estimate net benefit (Table 20). The results indicate that the combined intervention is more expensive (€43.12) and more effective (-1.12 days) at reducing absenteeism than the control. (However, the p-value of (p = 0.116) suggests that the difference in effects may not be statistically significant). The deterministic ICER is estimated at €39 per absent day avoided, which means that it costs €39 per employee for a reduction of one absent day.

The PSA results confirm the deterministic results that the combined intervention is more expensive and more effective than the control in terms of reducing absenteeism with an ICER of €38 per absent day avoided reported (Table 20). Figure 24 illustrates the uncertainty in the estimates of incremental costs and effects (absent days) when the combined intervention was compared to the control. These estimates were generated from the Monte Carlo Simulation in the PSA. The red point on the plane represents the average additional costs and the average reduction in absent days. This point lies in the North-Western quadrant of the ICE plane, demonstrating that the combined intervention is more expensive and more effective than the control. As was seen in the CUA, uncertainty surrounds the extent of the differences in costs between the combined intervention and the control (95th percentile range: €36.17 to €51.77). Uncertainty also surrounds the existence of differences in effectiveness between the combined intervention and the control and also with regards to the extent of the differences. The extent of this uncertainty is reflected in the 95th percentile range (-13.90 to 14.90 days).

Figure 24: Incremental cost-effectiveness plane (absenteeism): combined v's control



<u>Net benefit</u>

Using IBEC's estimate (51) of the daily cost of absenteeism per employee (€144.48) as the ceiling ratio, the net benefit of the combined intervention compared to the control was estimated. Recalling the equation of calculating net benefit (equation 2):

(Ceiling ratio ΔE) – ΔC >0*

Substituting IBEC's estimate (€144.48) for the ceiling ratio, 1.12 as the incremental benefits (reduction in absenteeism) and €43.12 as the incremental costs, the net benefit of the combined intervention compared to the control was calculated as follows:

(€144.48* 1.12) - €43.12 = €118.70

A positive net benefit per employee of €118.70 indicates that the benefits (a reduction of 1.12 days absent) exceed the cost of the combined intervention (€43.12) compared to the control. Therefore, from the employers' perspective, the combined intervention can be considered cost-effective. The PSA results confirm the CBA results with an estimated positive net benefit per employee of €114.40 generated from the Monte Carlo simulation in the PSA. The 95^{th} percentile range (€105.45 to €121.51) reflects the uncertainty in the net benefit estimated from the PSA.

6.6. Discussion

6.6.1. Overview of results

By applying standard economic evaluation methods to evidence from the FCW trial, this study sought to determine the cost-effectiveness of a complex workplace dietary intervention using a multifaceted approach from an employer's perspective. Each of the workplace dietary interventions (education, environment and combined) was compared to the control. The economic evaluation of each intervention consisted of a baseline CUA which measured the cost-effectiveness of the interventions in terms of QALYS. Sensitivity analyses were also conducted to test the robustness of the QALYS which consisted of performing CEAs using clinical measures (BMI, waist circumference and weight) to measure health outcomes. Finally, a CBA was employed whereby the monetary value of absenteeism was employed so as to report the net benefit of the intervention(s) compared to the control, from an employer's perspective. Also, Monte Carlo simulations were performed as part of the PSAs in order to assess parameter uncertainty. A summary of the economic evaluation results and a discussion of the implications of the results are presented in this section. The strengths and limitations of the economic evaluation are also discussed and suggestions for potential future research are made. Table 21 includes a summary of the main cost-effectiveness results for each of the interventions compared to the control.

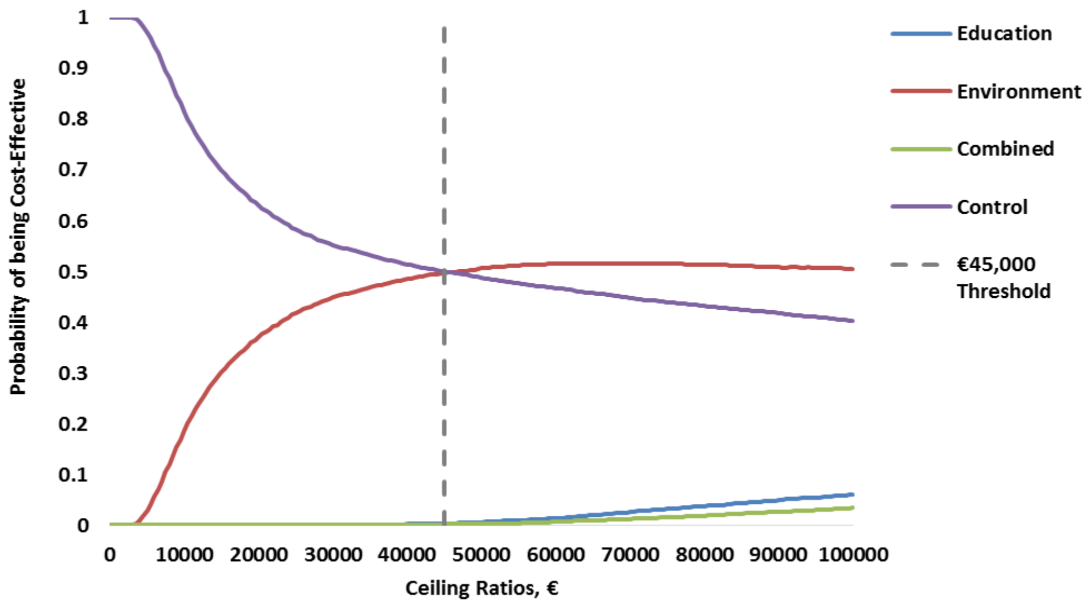
Table 21: Summary of ICERs: interventions v's control

		CUA	Sensitivity Analyses			CBA
			BMI	WC	Weight	Absenteeism
Education	ICER Deterministic	€970.55/QALY	€45.04/ kg/m^2	€19.57/cm	€17.31/kg	€54.50/day
	ICER Probabilistic	€1,075.14/QALY	€45.04/ kg/m^2	€20.28/cm	€17.36/kg	€53.98/day
						Net benefit: €61.84/employee
Environment	ICER Deterministic	€97.95/QALY	€14.22 /kg/m^2	€2.97/cm	€6.73/kg	€5.60/day
	ICER Probabilistic	€92.96/QALY	€14.04 /kg/m^2	€3.13/cm	€6.96/kg	€5.27/day
						Net benefit: €145.82/employee
Combined	ICER Deterministic	€2,156.05/QALY	€99.77 /kg/m^2	€22.23/cm	€37.54/kg	€38.55/day
	ICER Probabilistic	€2,686.61/QALY	€98.04 /kg/m^2	€22.03/cm	€38.78/kg	€37.66/day
						Net benefit: €118.70/employee

The baseline CUA demonstrates that each of the workplace dietary interventions (education, environment and combined) are more expensive and also more effective than the control. The environment intervention can be considered the most cost-effective intervention in terms of cost per improvement in QALYs, as it reported the lowest ICER of €98/QALY. This was followed by the education intervention (€971/QALY) and the combined intervention (€2,156/QALY). The PSA results confirmed the deterministic ICERs. These findings are owing to the fact that the environment intervention reported only marginal additional costs (€5.88) when compared to the control. In addition, although improvements in QALYs were small across each of the interventions, the largest improvements were observed in the environmental intervention (0.050 QALYs).

Although, each of the CUA ICERs fall below the benchmark threshold level of €45,000/QALY, it is important to discuss the uncertainty that surrounds these estimates. The ICE planes illustrate the considerable uncertainty that surrounds the incremental costs and incremental benefits for each intervention. This uncertainty is also reflected in the 95th percentile ratios that were presented for each intervention and was generated from the PSA. The CEAC presented in Figure 25 summarises the decision uncertainty in the incremental costs and incremental effects (QALYs) of each intervention compared to the control. The probability of each dietary intervention being cost-effective was plotted against a range of ceiling ratios (€0 to €100,000/QALY). This figure shows that at the benchmark cost-effectiveness threshold of €45,000/QALY, the probability of the environment intervention being cost effective compared to the control is 50%, while both the education and the combined interventions have less than 1% probability of being cost-effective compared to the control. It can be observed that at no ceiling ratio (€0 to €100,000/QALY) is the probability of being cost-effective for either the education or the combined interventions greater or equal to that for the control. Thus, it is evident that the uncertainty observed in the incremental costs and QALYs for the education and combined interventions, does not translate into decision uncertainty. With regards to the environment intervention, the uncertainty surrounding the incremental costs and QALYs does translate into decision uncertainty. As the ceiling ratio increases beyond €45,000, the probability of the environment intervention being cost-effective increases and falls for the control. This may be due to the fact that the environment intervention had only marginally higher costs than the control workplace and the additional benefits reported in the control were also low.

Figure 25: CEAC of interventions v's control



6.6.2. Appropriateness of ceiling ratio

It is important to discuss the suitability of the most recent Irish cost-effectiveness threshold (€45,000/QALY) as a decision rule for reimbursement and research and development decisions. The decision rule states that only healthcare interventions with a cost-effectiveness ratio below a given threshold are acceptable for reimbursement (154). Until recently, Ireland was one of few European countries to have an explicit cost-effectiveness threshold. As outlined in section 6.5 of this chapter, the threshold was established in 2012 on the basis of an agreement between the Irish Government and the pharmaceutical industry. The explicit threshold of €45,000/QALY replaced the previous unofficial threshold of €20,000/QALY (178). In the absence of a current threshold and within the context of the previous agreement, this economic evaluation used the explicit threshold as a benchmark. However, research suggests that the explicit threshold of €45,000/QALY was likely set too high. Reasons for this could be explained by its origins as it was set primarily for pharmaceutical reimbursement decisions. Nevertheless, a QALY is a measure of quality of life regardless of whether an intervention is pharmaceutical based or not. Recent research estimated an appropriate threshold for the UK based on the cost-effectiveness of services forgone of £13,000/QALY (178). This further indicates that the most recent Irish threshold is too high, owing to the assumption that Ireland's threshold should be comparable to the UK threshold (188). However, in this economic evaluation it can be observed from Figure 25 that even if the lower threshold of €20,000/QALY is considered, the probability of the interventions being cost-effective decreases even further. Recent research has called for a review of current threshold levels for instances where reimbursement decisions are being made regarding public health interventions (188). Within an Irish context, the new agreement between the IPHA and the Irish Government has opted for a non-specified dynamic decision threshold. Reimbursement and allocation decisions regarding new and existing pharmaceuticals will be determined by the Health Service Executive (HSE) for the next four years (179).

6.6.3. Suitability of QALYs

Internationally recognised health technology assessment (HTA) agencies such as NICE and ISPOR, strongly advocate the use of QALYs when conducting economic evaluations of health interventions. However, as outlined, concerns regarding the exclusive reliance on QALYs in resource allocation decisions have been raised (186, 187). One such concern is that QALYs may be insensitive to detect real changes in health-related quality of life and it has been argued that it is more appropriate to include measures of health that are specific to the intervention that is under consideration (187). In this study, in order to test the robustness of the QALYs and to investigate whether or not the baseline CUA cost-effectiveness results hold, outcome measurements that were specific to the workplace dietary interventions were used through sensitivity analyses. Outcome measures considered included BMI, midway waist circumference and weight. The results of the one-way sensitivity analyses (Table 21) indicate that the CUA cost-effectiveness results were confirmed in the CEA when the clinical measures for each intervention were employed. See Table 21 for results.

6.6.4. Role of CBA

This economic evaluation also consisted of a CBA where the net benefit of each intervention compared to the control was estimated. This was conducted from an employer's perspective. In instances where interventions are to be funded by private industry, the benefits need to be of relevance to the business. Monetising absenteeism facilitated the translation of the trial outcomes into realisable benefits for the business. Each intervention reported a positive net benefit (environment: €145.82 per employee, education: combined: €118.70 per employee and education: €61.84 per employee). However, it is important to note that these net benefit results are heavily dependent on the monetary estimate for absenteeism that was used in the economic evaluation. The daily estimate that was used in this economic evaluation (€144.48 per employee) was obtained from IBEC and adjusted for inflation (51). Currently, no other suitable estimate within the Irish context is available. However, it can be observed that even by reducing the daily monetary value of absenteeism to €72 per employee (half of IBEC's estimate), the net benefit remains positive for the three interventions (environment: €69.72 per employee, combined: €37.52 per employee and education: €11.83 per employee).

6.6.5. Perspective matters

The different interpretation of the results between the CBA and both the CUA and the sensitivity analyses highlight that the perspective taken in an economic evaluation matters. Based on the results of the CUA, neither the education intervention nor the combined intervention would be considered cost-effective with the control demonstrating a higher probability of being cost-effective across a range of ceiling ratios (€0 to €100,000/QALY). It could be argued that the environmental intervention has the potential to be cost-effective (50% probability of being cost-effective at a €45,000/QALY threshold). However, when the results of the CBA are considered alone from the perspective of an employer, all three of the interventions appear to be cost-effective due to their positive net-benefit. This demonstrates that the values that are placed on benefits can vary with the perspective of the economic evaluation and can therefore influence results and recommendations. Employers are likely to place a high value on a reduction in absenteeism which indicates that they are more likely to invest in a workplace intervention that has demonstrated a positive net benefit. The costs incurred from implementing and rolling out the intervention in the short term would be expected to be offset by the potential longer term cost savings that would be generated from an improvement in outcomes (i.e. a reduction in absenteeism, improvement in quality of life and clinical health outcomes). The results of the CBA may be capturing time preference, that is to say individuals place greater value on the short-term costs and benefits than those occurring in the future (154). This result suggests that employers are placing greater value on reducing current absenteeism rather than focusing on improving the future health outcomes of their employees. As this economic evaluation did not include long-term outcomes, the potential for costs to be offset in the long-term is unknown. Thus, when taking the perspective of the employer, the CBA results should be interpreted in a manner that gives consideration of the value that is placed on reducing absenteeism by an employer.

6.6.6. Future research

Linked to the previous concern of short and long term costs and benefits, it is important to acknowledge that this study captures high initial costs of implementing and delivering the interventions without incorporating long-term health outcomes. Each of the interventions reported improvements in all outcomes (QALYs, BMI, midway waist circumference and absenteeism). Nevertheless, in the absence of long term outcomes it is not feasible to determine whether or not these improvements will persist in the future. The inclusion of short term outcomes is a constraint of the actual FCW trial and not of the economic evaluation itself. Further research which includes long term outcomes is warranted in order to accurately determine the cost-effectiveness of complex workplace dietary interventions and to investigate if improvements persist in the future. The inclusion of long-term outcomes will also go towards reducing the uncertainty surrounding the effectiveness of the interventions which was illustrated on the ICE planes. Reducing the uncertainty around the estimates would increase the potential for the interventions to be considered cost-effective.

Moreover, it is likely that the cost-effectiveness of the interventions would improve over time if the interventions were to become more mainstream within the workplaces. For example, the set-up costs would be offset if the interventions were to continue over time and the training costs would also be reduced with the integration of the interventions into the workplace. Staff costs could also be reduced if a nutritionist was hired as a salaried employee of the workplace rather than on a consultancy basis which is likely to be more expensive. In addition, the cost-effectiveness of the interventions would also improve if the costs of the interventions were reduced. In this economic evaluation, it is important to note that the costs of the interventions are too high for the marginal benefits they are deriving. It can be observed that by reducing the total costs of each of the interventions, the corresponding ICERs also subsequently decrease.

Furthermore, the inclusion of long-term outcomes would allow researchers to assess whether or not the cost of the interventions would be reduced over time. However, it must be acknowledged that the inclusion of long-term outcomes may result in an improvement in cost-effectiveness rather than an improvement in outcomes. That is to say, the costs may decrease but the marginal improvement in benefits may persist.

The main strength of this study is that it contributes substantially to the current limited evidence base on the cost-effectiveness of workplace dietary interventions, providing a critical examination of such interventions. This study can be considered novel as it is one of the first studies to comprehensively integrate clinical effectiveness evidence with economic costs of workplace dietary interventions. The findings can be used to compliment and extend the current evidence that suggests workplace dietary interventions have the potential to improve employee health outcomes by reducing obesity levels and improving their health status (8, 9, 11, 12, 16). This economic evaluation provides employers, public health policy makers, national and international catering stakeholders and industry with robust cost-effectiveness evidence on complex workplace dietary interventions. From a public health policy perspective, workplace environmental modification strategies cannot be recommended for wide scale implementation until long-term outcomes are included and demonstrate that the improvements hold into the future.

6.7. Conclusion

This study has demonstrated that environmental modification interventions offer the most cost-effective approach for improving the health of employees and also provide a positive net benefit for employers. However, due to the considerable uncertainty that surrounds the differences in health effects between the intervention and the control, it is vital that before such environmental strategies are recommended for widespread implementation, future research which includes long-term outcomes needs to be conducted. The inclusion of long-term outcomes would allow for the initial high cost of implementing and rolling out the interventions to be spread over time and would also determine if improvements in outcomes persist into the future. Furthermore, the different results that emerged from this economic evaluation between the CUA and the CBA emphasise the importance of considering the perspective of an economic evaluation while interpreting the results. The perspective taken by an economic evaluation will influence the values that are placed on the outcomes of the intervention. These values will then in turn directly influence the results and the recommendations of the economic evaluation.

7. DISCUSSION

7.1. Overview of discussion

This thesis aimed to contribute to the current limited evidence regarding the implementation process of and the cost-effectiveness of complex workplace dietary interventions that include strategies of environmental modification and/or nutrition education. Firstly, this chapter describes the main findings of the thesis. Secondly, the main strengths and limitations of this thesis are discussed. Thirdly, the public health and policy implications of this thesis are summarised. Fourthly, areas for future research are proposed. Finally, the chapter closes with a concise conclusion of the thesis.

7.2. Main findings

Obesity, diet quality and absenteeism (Chapter 3)

This cross-sectional analysis was conducted to investigate the health status outcomes and lifestyle characteristics that influence the frequency of workplace absenteeism. Objective measures for both absenteeism and health status outcomes were included in an attempt to alleviate the uncertainty that is present in previous findings which have relied heavily on self-reported measures for both absenteeism and health status outcomes. The mean number of absent days was estimated at 2.5 days and after controlling for socio-demographic and lifestyle characteristics, the zinb model indicated that central obesity was positively associated with absenteeism and increased the expected absence rate by 72%. Consuming a high quality diet and engaging in moderate levels of physical activity were negatively associated with absenteeism and reduced expected frequency by 50% and 36% respectively.

The findings of this study can be used to guide and inform the development of workplace health promotion guidelines and policies. Specifically, the results indicate that an attempt to improve modifiable health and lifestyle characteristics including obesity, physical activity and diet quality should be at the core of such guidelines and polices to potentially reduce the rates of workplace absenteeism. The implementation of informed workplace health promotion polices may benefit the employers in terms of lowering rates of absenteeism and may also benefit employees in terms of improving their health status outcomes. The rate of absenteeism should be a concern for both employees and employers. Firstly, absenteeism can be an important personal and professional issue for employees. Secondly, data on absenteeism can play a key role in motivating employers to protect the health and well-being of their employees along with providing an economic incentive for reducing absenteeism.

Process evaluation (Chapter 4)

A detailed process evaluation which monitored and evaluated the implementation of the complex workplace dietary interventions was conducted. The process evaluation aimed to establish what factors facilitated or impeded the implementation of complex workplace dietary interventions. Semi-structured interviews were conducted with workplace stakeholders (managers, caterers and employees). The researchers who were involved in intervention implementation also took part in focus groups. Four principal themes emerged; perceived benefits of participation, negotiation and flexibility of the implementation team, viability and intensity of the interventions and workplace structures and cultures. Contextual factors were found to heavily influence implementation. Tacit workplace cultures including 'traditional' menu preferences and anticipated and realised resistance to change prevented full-scale implementation of the environmental intervention. The target-driven culture of manufacturing workplaces impeded implementation as the researchers involved in data collection experienced challenges in arranging appointments with employees. The results suggest that manufacturing production work rather than restrictive shift cycles impeded the implementation of a complex workplace dietary intervention. Organisational restructuring caused delays to the study timeline, attrition and disruptions to schedules. These barriers were eased by the flexibility and negotiation skills of the researchers. The adaptability of the implementation team was a vital facilitator for implementation and helped accommodate the impact of extensive organisational restructuring.

The findings of this study provide valuable insight into how concurrent process evaluations can effectively highlight the important barriers to and facilitators of implementing complex workplace dietary interventions. Perceived benefits of participation, stakeholder buy-in and organisational support are intrinsic facilitators of implementing workplace dietary interventions. Flexibility and negotiation play a pivotal role in overcoming the barriers of individual workplace cultures, structures and resistance to change. Interventions also need to be adaptable as the manufacturing companies need to tailor interventions to meet specific structural and cultural requirements of their workplaces.

In this area of workplace health promotion, concerns have been expressed with regards to whether or not interventions are primarily concerned with the agenda of employers in terms of reducing absenteeism. However, the process evaluation reveals that a shared agenda exists between employers and employees with regards to implementing workplace interventions. Employees want to improve their health outcomes and employers have demonstrated altruistic motives for improving the health and well-being of their employees. However, it is important to consider that evidence on potential cost savings has the potential to further motivate employers to implement workplace interventions.

Cost-analysis (Chapter 5)

The cost-analysis aimed to provide a detailed exposition of the costs associated with implementing and delivering a workplace nutrition education intervention, an environmental dietary modification intervention and a combined intervention from the perspective of an employer. The bottom-up, micro costing study identified two principal cost categories, staffing costs and printing and material costs. Physical assessment costs were also identified as a significant cost. However, as research costs were excluded from the analysis, physical assessment costs were omitted in the presentation of total costs. The study revealed that the combined intervention was the most expensive intervention to implement and deliver (€31,108) and the nutrition education intervention (€28,529) was found to be considerably more expensive than the environmental dietary modification intervention (€3,689) to implement and deliver. When physical assessment costs are added to the total costs, the combined intervention remained the most expensive intervention to implement and deliver (€47,305), followed by the nutrition education intervention (€44,726) and the environmental modification intervention (€24,474). The findings indicate that the implementation and maintenance of environmental dietary modification strategies in the workplace add minimal additional cost to the control when compared to nutrition education strategies.

Within multi-component interventions, the relative cost of implementing and delivering nutrition education elements is high compared to environmental modification strategies. A workplace environmental modification strategy added marginal additional cost, relative to the control. Nutrition education interventions and combined interventions are more expensive owing to the set-up and maintenance costs associated with the education strategies, demonstrating the need for careful consideration when selecting suitable education elements. Findings will inform employers and public health policy-makers regarding the economic feasibility of implementing and scaling dietary interventions. The findings were also used to inform the economic evaluation of the FCW study.

<u>Economic evaluation (Chapter 6)</u>

The study aimed to employ a multifaceted economic evaluation of nutrition education, environmental dietary modification and combined workplace interventions. Objective effectiveness evidence from the earlier intervention trial of the FCW study (BMI, midway waist circumference, weight, EQ-5D data and absenteeism) and the costs that were identified in the cost-analysis informed the economic evaluation. A baseline CUA indicated that each intervention (education (€37.85/QALY), environment (€5.88/QALY) and combined (€43.12/QALY)) is cost-effective when compared to the control in terms of ICERs. The results of the PSA demonstrate that there is no uncertainty surrounding the existence of differences in costs but that there is uncertainty surrounding the extent of the differences between each intervention and the control. Uncertainty also surrounds the existence and extent of differences in effects between each intervention and the control. In addition, as demonstrated on the CEACs, the uncertainty in the incremental costs and effects translates into decision uncertainty only for the environment intervention (50% probability of being cost-effective at €45,000/QALY threshold). Conversely, at no point between a ceiling ratio of €0 to €100,000 do the education and combined interventions have a higher probability of being cost-effective than the control. The results of the three secondary CEA confirmed the baseline CUA results for each intervention. The environmental intervention reported the lowest ICERs for: BMI (€14/kg/m^2), midway waist circumference (€3/cm) and weight (€7/kg). The CBA revealed that each of the interventions can be considered cost-effective when considered from an employer's perspective as each intervention reported a positive net benefit (environment: €145.82 per employee, education: €61.84 and combined: €118.70).

This study has demonstrated that environmental modification interventions offer the most cost-effective approach for improving the health of employees and also provide a positive net benefit for employers. However, it is clear that future research which includes long-term outcomes due to the considerable uncertainty that surrounds the differences in health effects between the intervention and the control is needed. It is vital that this research is conducted before such environmental strategies are recommended for widespread implementation. The inclusion of long-term outcomes would allow for the initial high cost of implementing and rolling out the interventions to be spread over time. In addition, long-term outcomes would also determine if improvements in outcomes persist into the future and would reduce the uncertainty surrounding the effectiveness of the interventions.

Furthermore, the different cost-effectiveness results that emerged between the CUA and the CBA emphasise the importance of considering the perspective of an economic evaluation when conducting an economic evaluation and when interpreting the results. From an employer's perspective each of the interventions can be considered cost-effective as they all reported positive net benefits. Conversely, due to the considerable uncertainty that surrounds the differences in clinical and quality of life outcomes between the interventions and the control the CUA results indicate that the interventions have a low probability of being cost-effective. This can be explained by the fact that the results of the CBA may be capturing time preference. That is to say, employers will place greater value on reducing absenteeism in the here and now rather than on improving the quality of life and health outcomes of their employees, of which the latter would have longer term benefits but would not be realised until the future.

7.3. Strengths and limitations

This section provides a summary of the key overall strengths and limitations of the thesis. The strengths and limitations of each of the four original research papers in this thesis have been acknowledged and addressed in the previous chapters.

Strengths

This thesis has a number of strengths. The research addressed a critical area of public health. The WHO is aiming to achieve a 25% reduction in global premature mortality from NCDs by 2025 and has identified a number of policy options to help achieve this goal. One of the policy options is concerned with promoting a healthy diet that is low in fat, saturated fat, trans fat, sugar and salt. The WHO recognises that the surrounding environment in which an individual lives and works has the potential to heavily influence their overall health status and that of their family and wider society. Furthermore, the WHO has identified the workplace as a priority environment for health promotion and acknowledges that by altering the environment through workplace dietary interventions can serve as an important catalyst for dietary behaviour change. However, the effectiveness and cost-effectiveness of workplace dietary interventions remains poorly defined due to a paucity of evidence. Linked to this issue of effectiveness and cost-effectiveness, there is a growing appreciation for the need for rigorous evaluation of the implementation process to investigate this uncertainty. This thesis examines the cost-effectiveness and implementation process of complex dietary interventions within the work environment.

A further strength of this thesis is concerned with the data source, the FCW study. The FCW study is the first high-intensity complex workplace dietary intervention study to measure the effectiveness of environmental dietary modification and nutrition education both alone and in combination. The study design was informed and developed according to a comprehensive systematic review and an academically rigorous framework (MRC framework) and guidelines (NICE guidelines). Data was obtained from participants in a standardised manner according to a study SOP manual and the research assistants were trained before and during data collection. Furthermore, data was collected using objective outcomes for health status outcomes and absenteeism. All of the workplaces had comparable working structures and operations as they were all manufacturing workplaces and employees had similar work schedules (i.e. shift workers, production workers and office workers). Employees (both participating and non-participating employees) had comparable demographics, education status, and health status and lifestyle characteristics at baseline. In addition, risk of contamination between workplaces was low as they were located in different geographical regions in Cork and employees were masked to the hypothesis of the study.

Essential practical and epidemiological considerations were accounted for during the conduct and reporting of the research studies included in this thesis. The presence of multicollinearity between variables (diet quality, physical activity, BMI and obesity variables) was considered. The use of objective, recorded absenteeism data reduced the potential for measurement error, recall and social desirability bias. The micro-costing method employed for costing the interventions ensures a high-level of precision in the cost estimates within the participating workplaces. Furthermore, the credibility, transferability, dependability and confirmability of the process evaluation results were ensured through the adherence to Guba's framework (1981) for assessing the trustworthiness of qualitative research.

Specifically, a key strength of this thesis lies in the substantial contribution that the novel findings make to a limited evidence base. This thesis is the first to report findings on evaluation of processes along with evaluation of effectiveness of complex workplace dietary interventions. The originality of the research is further highlighted by the fact that previous studies have also neglected to report evaluation of clinical outcomes alongside evaluation of economic cost outcomes.

A further strength of this thesis is that it addressed a timely and relevant research area within the Irish context. The relevance of the findings is highlighted as this work has been presented at scientific conferences both nationally and internationally (Appendix 3). Furthermore, to date, two of the four original research papers have been published in peer reviewed scientific journals, the third paper is currently under peer review and the fourth paper is in preparation for submission to a scientific journal (Appendix 5). In addition, this work has also attracted attention from national print media (Appendix 3).

Limitations

The main limitations of this thesis are associated with constraints of the actual FCW trial. The FCW study was a pragmatic trial which measured the effectiveness of the dietary interventions in ideal settings. The use of a cluster non-randomised design limits the generalisability of the findings (57, 189). The workplaces were purposively selected as ideal settings in which to implement the FCW interventions and were therefore not representative of all workplaces. There is a need for caution when interpreting the findings of a cluster non-randomised controlled trial due to their vulnerability to different types of bias. Firstly, allocation concealment is a concern. The researchers that were involved in data collection and intervention implementation were not blinded to the allocation of the interventions which means the study was open to interviewer bias. Secondly, selection bias may have also been introduced to the data as healthy employees may have been more likely to participate in the FCW study when compared to unhealthier employees. Thirdly, the self-reported nature of the questionnaires and 24-hour dietary recalls may have also been subject to measurement bias and also social desirability bias.

The limitations associated with the use of cross-sectional methodology must also be acknowledged. The main concern with interpreting the results of a cross-sectional study relates to the direction of effect. It is not possible to be absolutely certain that the cause preceded the effect as both the cause and effect are measured at the same time. For example, in this thesis there is potential for reverse causality to be present between obesity and absenteeism (i.e. is it the increase in central obesity that leads to an increase in absenteeism or is it the increase in absenteeism that leads to an increase in central obesity).

In addition to this fundamental epidemiological concern of scientific inference, the issue of confounding, particularly residual confounding must be considered. Despite adjusting for a wide range of potential confounders, concerns remain that not all of these potential confounders were measured with adequate precision. It should also be noted that there may be additional confounding that were not even considered. Given the non-randomised design, it may also be the case that potential confounders were not equally distributed across the four workplaces. Thus, there is a clear need for a further large scale cluster randomised controlled trial to accurately measure the effectiveness of the FCW interventions. A randomised controlled trial provides a solid foundation for causal inference as potential confounding factors are equally distributed across all arms of the study. The FCW research team have applied for the HRB Health Research Awards 2016 to secure funding to conduct a cluster randomised controlled trial design with a larger number of clusters and a longer follow-up period (2 years). The candidate contributed to the drafting of this proposal which is outlined in section 7.5 of this chapter.

A further limitation of this thesis is that despite the precision in the cost-estimates that were obtained for this thesis, the estimates were derived from specific dietary interventions that were implemented in atypical workplaces. Thus, the generalisability of the results is limited and their interpretation must be tentative. Furthermore, this study captures the high initial costs of implementing and delivering the interventions without incorporating long-term outcomes. In the absence of long term outcomes, it is not feasible to determine whether or not improvements in the outcomes will persist in the future. The inclusion of short term outcomes is a further constraint of the actual FCW trial and not of the thesis itself.

7.4. Public health and policy implications

This thesis builds on the earlier work that has been carried out as part of the FCW study which concludes that within a social-ecological framework that includes elements of 'nudge' theory, population-based workplace dietary interventions that are comprised of low-agency strategies may be an effective approach for promoting a healthy diet and weight loss in the workplace. The findings from this thesis provide vital evidence on the cost-effectiveness of complex workplace dietary interventions that incorporate environmental modification and nutrition education strategies. Important evidence on the factors that impede and facilitate the implementation of such interventions is also provided. This thesis has the potential to influence public health policy makers, national and international catering stakeholders and workplace stakeholders. It is important to recognise that not every public health intervention can be implemented. There is a need to prioritise the funding of interventions based on their relative cost-effectiveness, which was one of the core focus areas of this thesis. Based on the findings of this economic evaluation, the workplace intervention that appears to be the most scalable is the environmental modification intervention. Nevertheless, there is a clear need for caution when interpreting the results of the economic evaluation as the cost-effectiveness of the interventions change depending on what perspective is taken. There is a need for the trial to be replicated using a robust fully randomised study design with the inclusion of long-term clinical and cost outcomes.

This thesis has a number of public health implications. Public health has been defined as "the art and science of preventing disease, prolonging life and promoting health through the organised efforts of society"(190). This involves preventing illness and promoting health and well-being by using all levers of society from an individual level up to a systems level. Historically, the development of public health began in the 18th century with the sanitary movement with a focus on 'contagion' and the struggle against infectious disease. This movement emerged in response to growing urbanisation and industrialisation (191). In the 20th century, there was a shift in focus to preventive medicine which coincided with improvements in scientific medicine and acceptance of its potential benefits and achievements. Later in the 20th century, the dominance of the medical model began to waiver with focus being placed on building healthy public policy. This shift in focus was largely driven by the publication of the WHO's Alma Ata in 1978 which stated that there is a 'need for urgent action by all governments, all health and development workers and the world community to protect and promote the health of all the people in the world' (192). This was again reinforced in the Ottawa Charter in 1986 which specified the need to integrate each of following approaches to promote population health (193):

1. Building healthy public policy
2. Creating supportive environments
3. Strengthening community actions
4. Developing personal skills
5. Reorienting health services

6. Demonstrating a commitment to health promotion

Following the publication of the Ottawa Charter, workplace health promotion emerged as an important area of public health in the 21st century (creating supportive environments) (67). It was seen as an opportunity to facilitate the development of health promotion activities that use a holistic approach, incorporating both individual risk factors and the wider environmental and organisational workplace factors. In the early stages of workplace health promotion (1970s) the focus was individual based and huge emphasis was placed on health education approaches (67). However, in more recent times due to a combination of an increasing awareness of the limits of health education, an improved understanding of the determinants of health and guidance from the Ottawa Charter, workplace health promotion evolved from delivering health promotion programmes targeted at individual employees. It is now recognised that workplace health promotion should incorporate a sustainable multi-level approach with inputs from both employees and workplace management stakeholders in order to improve the health of employees, their families and wider society (23, 67).

The findings of this thesis indicate that having a shared agenda between employees and workplace management stakeholders is likely to facilitate the implementation of workplace dietary interventions. Thus, future workplace health promotion interventions should combine the efforts of both employees and workplace management stakeholders and intervene at multiple levels of the workplace environment. By adopting this approach these interventions are likely to be successfully implemented and may serve as an ideal way to improve the health of employees, their families and other community members.

7.5. Future research recommendations

In order to accurately test the effectiveness of complex workplace dietary interventions, a robust study design would be ideally employed. It is important that comprehensive and long-term evaluations which include long-term clinical and cost outcomes are undertaken to achieve more definitive conclusions about their effectiveness and cost-effectiveness. As mentioned previously, the FCW research team have applied for the HRB Health Research Awards 2016 to secure funding to conduct a cluster randomised controlled trial design. It is proposed that the long-term effectiveness of a complex workplace intervention that combines environmental dietary modification, nutrition education and physical activity will be assessed. A physical activity element will be incorporated into the intervention in response to workplace stakeholders' comments during the FCW non-randomised study. Daily step pedometers will be used to measure physical activity.

Similar to the FCW study, the fully randomised controlled trial will be organised into three interlinked work packages which will include the 'Food Choice at Work and Exercise' intervention trial (work package 1), a detailed process evaluation (work package 2) and a comprehensive economic evaluation to assess the long-term cost-effectiveness of the intervention (work package 3). The intervention will be tested using a partially blinded, blocked randomised controlled trial design within 16 manufacturing workplaces over a period of 2 years in the Cork and Kerry region.

A diverse working population will be recruited (i.e. blue collar vs. white collar, ethnicity, age groups, education status) to assess the effectiveness of the intervention on employees' dietary behaviours, nutrition knowledge, health status and physical activity levels. It is also proposed that additional objective outcome measures including blood lipids (cholesterol, HDL and LDL) and food sales data to obtain employees' food consumption patterns at work will also be collected. Economic cost outcomes including recorded absenteeism trends and intervention costs will also be collected. If the funding application is successful, it is envisaged that this trial will be conducted by the same research team as the FCW study.

The study will address the clear need for translational population health research in the area of dietary and physical activity research and will support national disease prevention strategies. It is envisaged that the findings will be used to inform national and international catering stakeholders, employers and public health policy makers. The study will provide critical evidence on the effectiveness and cost-effectiveness of a complex workplace intervention in the promotion of healthy dietary and physical activity behaviours in the general Irish working population.

Furthermore, the FCW study has been fully commercialised as a spin-out company of University College Cork. The commercialisation process has provided valuable insights into how scientific research can be successfully linked to industry. Although the economic evaluation of the FCW trial indicates that low-autonomy environmental modification strategies offer the most cost-effective approach for improving employee health, absenteeism rates and generating a positive net benefit, employers are opting to invest in a less cost-effective workplace programme that includes both environmental modification and nutrition education strategies. This is due to the fact that employees engage more with programmes that are more visual and interactive within their workplace environment. Feedback provided by employers and employees from workplaces who have signed up to the commercialised FCW programme, revealed that employees are seeking ‘personalised plans’ from nutritionists and wish to feel like they have access to their very own ‘operation transformation’ style programme, with regular input from health experts. Similarly, it was revealed that employers were more likely to invest in a combined programme. The reasons for this are two-fold, employers felt that the more interactive the programme is, the more value they will be deriving from their investment and they also felt that implementing an ‘obvious’ interactive workplace programme would foster employee loyalty and improve employee retention levels. Future workplace health interventions that are focused on environmental modification strategies should consider that in order to secure both employer and employee buy-in, elements of nutrition education should also be offered.

7.6. Conclusions

Employees and employers have a shared agenda with regards to the implementation of workplace dietary interventions. Employees wish to improve their health outcomes and employers have demonstrated altruistic motives for improving the health of their employees. The potential for cost savings is also motivating employers however, evidence on the cost-effectiveness of complex workplace dietary interventions is limited. The findings from this thesis indicate that environmental modification interventions offer the most cost-effective approach for improving the health of employees and also provide a positive net benefit for employers. However, it is imperative that before such environmental strategies are recommended for widespread implementation in local, national and international workplaces, future research which includes long-term outcomes needs to be conducted. Such research will reveal whether or not the modification of workplace environments can actually have a positive impact on working towards achieving the WHO's targets of reducing global NCD deaths and halting the escalating prevalence of and associated human and economic burden of obesity. This research will also allow for an investigation of whether or not low-agency 'nudge' environmental modification strategies can effectively serve as economically sustainable population level obesity prevention strategies.

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9. APPENDICES

<u>Appendix 1:</u> Topic guides used in Process Evaluation

<u>Topic Guide for Employees – Baseline stage</u>

A) <u>Lead in – current situation</u>

1) Can you give me a brief overview of your current position within this company?

- How many years have you worked here?
- How many hours a day/week do you spend at this worksite?
- How much time is allocated for lunch breaks and how do you spend this time?

B) <u>Health and diet</u>

1) Do you regard yourself as being a 'health conscious' person?

- Yes/no/in what way?

2) How would you describe your diet? Do you take steps to meet your dietary needs? E.g. eating your 5-a-day

3) What areas could you improve on?

4) Can you tell me a bit about your diet and eating habits at work?

5) What are your favourite foods?

6) Does your diet vary with the seasons?

7) What do you drink with your meals generally?

8) Do you have regular meals or do you snack frequently?

C) <u>Influence on food choice at work</u>

1) What factors influence your food choice at work?

2) What do you think about the selection of food on offer in the canteen?

3) Do you think enough variety is provided?

4) What do you think of the quality of food available?

5) What do you think of the affordability of food in the canteen?

6) What would you eat in the canteen on a typical day?

7) What would encourage you to eat more healthily in the workplace?

D) <u>Previous involvement in workplace interventions/opinions on canteen food</u>

1) Have you ever been involved in a workplace health promotion programme either here or in a previous workplace?

- If so what did it entail?

2) What is your opinion on the food available in the canteen?

3) What is the general view among fellow employees?

4) What changes would you make to the food available if given the opportunity?

5) What kinds of meals are available?

6) Is there a wide range of choice?

7) Are low calorie options available?

8) If not, do you think healthier meals should be made available?

9) Where do you think the responsibility lies in making this a healthier workplace and ensuring that employees get nutritious and balanced meals?

E) <u>Expectations of the Food Choice at Work Intervention</u>

1) What does this study entail for you?

2) How do you feel about participating in the food study?

3) What is the general view among your colleagues?

4) What you do expect from the forthcoming programme?

5) Do you perceive any benefits to yourself?

6) Is the study a topic of conversation amongst you and your colleagues?

7) Determine if there is enthusiasm/negativity for the intervention.

8) Do you have any issues/concerns about the study?

F) <u>Barriers to the success of the intervention</u>

1) How is the study being received by your colleagues?

2) Do you think there will be any barriers to the success of the study?

3) Is there willingness for change in the workplace?

4) Do you think people will be honest in their answers?

5) What benefits (if any) do you envisage for yourself and your colleagues due to involvement in this study?

G) <u>Debriefing/conclusion</u>

Thank the interviewee for their time and effort and ask if they have any questions or anything more to add. Conclude the interview if there is no further questions and comment briefly on main findings or interesting comments which may spark further feedback. Reassure participant around issues of confidentiality, anonymity and privacy and state that findings will not reveal personal details.

Appendix 2: Supplementary information for Chapter 6

Description of the four different types of economic evaluation methods:

1. Cost-minimisation analysis: This type of economic evaluation is undertaken in circumstances where the benefits of two or more competing technologies have been proven to be equal. Only the costs of the technologies are compared and the alternative with the lowest net cost is favoured. As this is a type of partial economic analysis, it is considered to be of limited use.

2. Cost-benefit analysis: In cost-benefit analysis both the costs and benefits (both health outcomes and non-health outcomes) of the intervention and comparator technologies are assessed in monetary units. This allows for the direct comparisons of incremental costs with incremental outcomes. The economic summary measure used in CBA is net benefit (154).

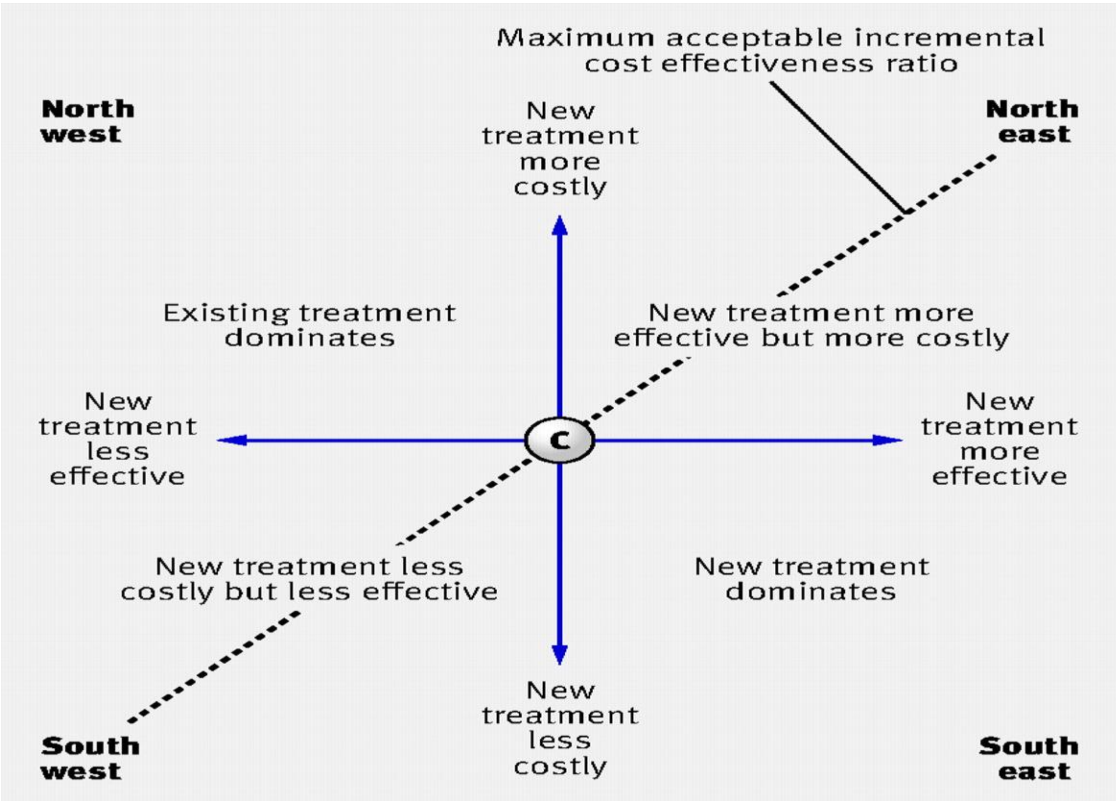
3. Cost-effectiveness analysis: This type of economic evaluation compares technologies that produce a similar health effect. Costs are measured in monetary units while the outcomes are measured in natural units such as life-years gained, reduction in body weight or reduction in blood pressure. CEA informs allocation decisions with regards to how much additional benefit can be achieved from a technology for the additional costs that are incurred. Cost-effectiveness ratios are typically used as economic summary measures in CEA (154, 172).

4. <u>Cost-utility analysis:</u> This type of economic evaluation measures costs in monetary units and benefits are measured using a utility measurement. CUA is similar to CEA, but has a specific focus on capturing the quality and quantity of life in order to compare different interventions. In CUA, the incremental cost of a technology from a particular perspective is compared to the incremental health improvement attributable to the technology (154, 172). QALYs which represent both the quality and quantity of life lived are the most frequently used health outcome measures in CUA. Alternative outcome measures, such as DALYs are used less frequently in CUA. These outcome measures integrate the changes in both quality and quantity of life. CUA report the cost per DALY gained or cost per QALY gained. (154).

<u>Sample of an Incremental Cost-Effectiveness Plane</u>

An incremental cost-effectiveness (ICE) plane is a four quadrant diagram which plots the incremental costs and outcomes/benefits/effects of an intervention that is under consideration compared to an alternative. The incremental costs are plotted on the vertical (y) axis and the incremental effects are plotted on the horizontal (x) axis. If an ICER lies in the north-west quadrant it indicates that the new intervention has higher costs and is less effective than the control and is said to be dominated by the control. If an ICER lies in the south-east quadrant it indicates that the intervention is less costly and more effective than the control and it is said to dominate the control. If an ICER lies in the north-east quadrant it indicates that the intervention has higher costs and is also more effective than the control. If an ICER lies in the south-west quadrant it indicates that the intervention is less costly and less effective than the control. In the latter two instances, a decision rule is necessary. This involves using a threshold ceiling ratio to represent how much society is willing to pay for the additional effects (i.e. improvement in QALYs). The ICER is compared to this maximum acceptable ICER threshold value in order to determine if the intervention under consideration represents an efficient use of resources.

Figure 26: Sample of an incremental cost-effectiveness plane



(*Source: adapted from Drummond et al (154)*)

<u>Construction of a Cost-Effectiveness Acceptability Curve (CEAC):</u>

Cost-effectiveness acceptability curves (CEAC) are used as a method for quantifying and graphically summarising decision uncertainty on cost-effectiveness in economic evaluations. A CEAC illustrates the probability of an intervention being cost-effective compared to an alternative intervention for a range of maximum willingness to pay values for an additional unit of outcome. A CEAC is derived from the joint distribution of incremental costs and incremental effects. These joint distributions can be estimated from a Monte Carlo simulation which is displayed on an ICE plane (181).

The sample ICE pane (Figure 26) can be used to illustrate the decision rule that indicates that points that fall below and to the right of the line (south and east) representing the maximum acceptable ICER indicate that the intervention is cost-effective. Using the results of a Monte Carlo simulation, the probability of the technology being cost-effective is estimated as the number of points falling in this region (below the maximum acceptable ICER line) as a proportion of all the points. This figure can be used to summarise uncertainty as the probability that the technology is cost-effective at that ceiling ratio (176, 182). This can be repeated for all potential values of the ceiling ratio (€0 to €100,000), with lines through the origin representing different willingness to pay thresholds for additional units of effectiveness (additional QALYs). The probability of cost-effectiveness at each ceiling ratio can then be plotted on to the CEAC. Ceiling ratios are plotted on to the x-axis and the probability of the intervention being cost-effective is plotted onto the y-axis. As the CEAC summarises the evidence supporting the intervention being cost-effective at different values of the ceiling ratio, it is said that the CEAC illustrates the decision uncertainty in an economic evaluation. When more than two interventions are being compared, multiple CEACs can be presented on the one graph whereby there is an acceptability curve representing each intervention. As the interventions are all mutually exclusive, the CEACs should sum to the probability of one (vertical axis on the graph). It is also important to note that a CEAC is restricted to presenting the probability of an intervention being cost-effective compared to an alternative intervention for a range of values; it should not be used to make recommendations about the adoption/implementation of an intervention (182).

<u>PSA: Monte Carlo Simulation</u>

Probabilistic Sensitivity Analysis (PSA) is used in economic evaluations to deal with parameter uncertainty in economic evaluations. The first stage of PSA is concerned with characterising the uncertainty in the input parameters (costs and effects). This is achieved by assigning probability distributions to the parameters. The second stage of PSA is to assess the implications for the results of the study of the uncertainty in all of the input parameters simultaneously. The process of propagating parameter uncertainty through the model is most commonly undertaken using a Monte Carlo simulation. This is a type of simulation that is dependent on repeated random sampling to generate results and is often referred to as the 'what-if' analysis. The deterministic analysis does not take into account the variations (uncertainty) in the input parameters. Monte Carlo simulation can provide a way of assessing a wide range of uncertainty associated with each input parameter. Once the probability distributions are assigned to the parameters, random samples from each distribution are drawn. The expected values are calculated a large number of times, with each iteration involving a random draw from each of the input parameter distributions. This generates a large number (e.g.

10,000) of sets of expected costs and effects that reflect the joint parameter uncertainty in the model which can be employed to inform the adoption/reimbursement decision.

<u>Appendix 3</u>: Research output, dissemination, training and contributions

Research from this thesis has been published in peer-reviewed academic journals (Table 22) and has been presented at national and international conferences (Table 24). The candidate has also contributed to other publications while completing this thesis (Table 23) and has completed academic modules and training (Table 25). Furthermore, the candidate has made significant contributions to the Department of Epidemiology and Public Health, UCC while completing this PhD (Table 26).

Table 22: Peer-reviewed publications from this thesis

	Year	References for peer-reviewed journals
1	2016	**Fitzgerald S**, Geaney F, Kelly C, McHugh S and Perry IJ: Barriers to and facilitators of implementing complex workplace dietary interventions: process evaluation results of a cluster controlled trial. *BMC Health Services Research 2016,* 16:139.
2	2016	**Fitzgerald S**, Kirby A, Murphy A and Geaney F: Obesity, diet quality and absenteeism in a working population. *Public Health Nutrition 2016*, 1:9.
3	2016	**Fitzgerald S,** Kirby A, Murphy A, Geaney F and Perry IJ: A cost-analysis of complex workplace nutrition education and environmental dietary modification interventions. Currently under review with *BMC Public Health.*
4	2016	**Fitzgerald S**, Murphy A, Kirby A, Geaney F and Perry IJ: A cost-effectiveness analysis of complex workplace dietary interventions. Will be submitted to *BMJ* in October 2016.

Table 23: Other peer-reviewed publications

	Year	References for peer-reviewed journals
1	2014	Dee A, Kearns K, O' Neill C, Sharp L, Staines A, O' Dwyer V, **Fitzgerald S** and Perry IJ: The direct and indirect costs of both overweight and obesity: a systematic review. *BMC Research Notes 2014*, 7:242.
2	2015	Geaney F, **Fitzgerald S,** Harrington JM, Kelly C, Greiner BA and Perry IJ: Nutrition knowledge, diet quality and hypertension in a working population. *Preventive Medicine Reports 2015,* 2:105-113.
3	2015	Tracey ML, **Fitzgerald S**, Geaney F, Perry IJ and Greiner B: Socioeconomic inequalities of cardiovascular risk factors among manufacturing employees in the Republic of Ireland: A cross-sectional study. *Preventive Medicine Reports 2015*, 2:699-703.
4	2015	Dee A, Callan A, Doherty E, O' Neill C, McVeigh T, Sweeney MR, Staines A, Kearns K, **Fitzgerald S,** Sharp L, Kee F, Hughes J, Balanda K and Perry IJ: Overweight and obesity on the island of Ireland: an estimation of costs. *BMJ Open 2015*, 5:3.

Table 24: Conference presentations during the PhD

Month/ Year	Conference	Title	Presentation
September/ 2013	Nutrition and Health Foundation, Annual Seminar, The Gibson Hotel, Dublin.	Food Choice at Work Study: The long term impact of workplace dietary modification interventions on dietary behaviours and diet-related disease risk.	Oral
May/2014	Royal College of Physicians of Ireland, Faculty of Public Health Medicine, Summer Scientific Meeting, RCPI, Dublin.	Survey on the availability of calorie-dense snack food in Irish post-primary schools.	Oral
May/ 2015	Global Implementation Conference, The Convention Centre, Dublin.	Barriers to and facilitators of implementing complex workplace dietary interventions: process evaluation results from the Food Choice at Work Study.	Oral
July/2015	International Health Economics Association, World Congress in Health Economics, Bocconi University, Milan, Italy.	Absenteeism in the workplace: results from the Food Choice at Work Study.	Oral

February/2016	The 2nd Annual SPHeRE Network Conference, RCSI, Dublin.	Obesity, diet quality and absenteeism in a working population.	Oral
June/2016	The International Society of Behavioural Nutrition and Physical Activity (ISBNPA) Annual Meeting, Cape Town International Convention Centre, Cape Town, South Africa.	1.Obesity, diet quality and absenteeism in the workplace. 2.A cost-analysis of complex workplace dietary interventions.	Oral Poster
Example of media coverage of PhD output:			
11th July 2016	The Irish Examiner	'Study shows absentee rate increases with obesity levels'. Print media and online version: www.irishexaminer.com/ireland/study-shows-absentee-rate-increases-with-obesity-level-409543.html	

:

Table 25: Courses completed during PhD

	Course modules	Date completed	Credits awarded
1	EH7003: Evidence Synthesis and Clinical Trials Result achieved: 1H	May 2013	5
2	EH7005: Intro to Health Economics and Econometrics. Result achieved: 2H	May 2013	10
3	EH7009: Population and Individual Health Result achieved: 2H	May 2013	10
4	EH7010: Health Systems, Policy and Informatics Result achieved: 2H	May 2013	10
5	EH7011: Interrogation, Interpreting and Reporting Result achieved: 1H	May 2013	10
6	EC6015: Evaluating Health Outcomes 1 Result achieved: 1H	January 2016	5
7	EC6016: Evaluating Health Outcomes 2 Result achieved: 1H	May 2016	5
8	Health Economic Evaluation Workshops, Health Economics Group at School of Economics, UCC.	October 2014 – January 2015	Cert of attendance awarded
9	NVivo Training Workshop, UCC.	November 2014	Cert of attendance awarded

Table 26: Contributions to the Department of Epidemiology & Public Health

Task	Details of contribution
Site leader for FCW fieldwork	Site leader for the environmental modification workplace. Responsible for the coordination of data collection and communication with workplace stakeholders (2012-2015).
Research assistant	Research assistant on the *Safe*food project 'Cost of Overweight and Obesity' (2013 -2014). Contributed to the drafting of two peer-reviewed publications.
Tutor	Tutored 2 Master in Public Health students (2013-2014).
BSc mentoring	Mentored 10 first year BSc Public Health students in EH1006: Perspectives of Public Health, (2014 – 2015).
Online tutor	Online tutor for the MSc in Occupation Health. EH6065: Research Methods and Information Retrieval in Occupational Health, (2015).
Co supervisor	Co-supervisor of a Master in Public Health student who is using the FCW process evaluation data (2016).
Teaching	Delivered lectures to 1st year BSc Public Health students for the following sessions in EH1006: Perspectives of Public Health, (2013 – 2016): • Working with data • Perspectives on public health
Funding	Awarded the following bursaries: • The Nutrition and Health Foundation (NHF) research bursary in 2013 • The School of Medicine and Health Travel Bursary in 2015. Contributed to the writing of a number of grant applications, including: • Research bursaries awarded from the Irish Heart Foundation (IHF) (2013 and 2014) • Donations received from some of the study workplaces

<u>Appendix 4:</u> Questionnaires used in FCW Study

Office Use Only   Self completed Yes ☐ No ☐

Study Number ☐☐☐ ☐☐☐☐

Worksite ☐☐☐

Confidential

EQ-5D Questionnaire

Thank you for taking the time to complete this questionnaire. Your time and information is greatly valued.

The questionnaire is organised into two sections which contain questions on your overall health status. Please read the question and instructions carefully and complete each section to the best of your ability.

It takes approximately 5 minutes to complete.

<u>Instructions:</u>

Please answer the following questions by filling in the appropriate boxes (as per example below) or by writing the answer in the space provided.

Self-completed example: **Are you male or female?** Male ■ Female ☐

1

Under each heading, please tick the ONE box that best describes your health TODAY.

1. Mobility:
Please tick only one box.

I have no problems in walking about ☐
I have slight problems in walking about ☐
I have moderate problems in walking about ☐
I have severe problems in walking about ☐
I am unable to walk about ☐

2. Self-care:
Please tick only one box.

I have no problems washing or dressing myself ☐
I have slight problems washing or dressing myself ☐
I have moderate problems washing or dressing ☐
I have severe problems in washing or dressing myself ☐
I am unable to wash or dress myself ☐

3. Usual activities (e.g. work, study, housework, family or leisure activities):
Please tick only one box

I have no problem doing my usual activities ☐
I have slight problems doing my usual activities ☐
I have moderate problems doing my usual activities ☐
I have severe problems doing my usual activities ☐
I am unable to do my usual activities ☐

4. Pain/discomfort:
Please tick only one box

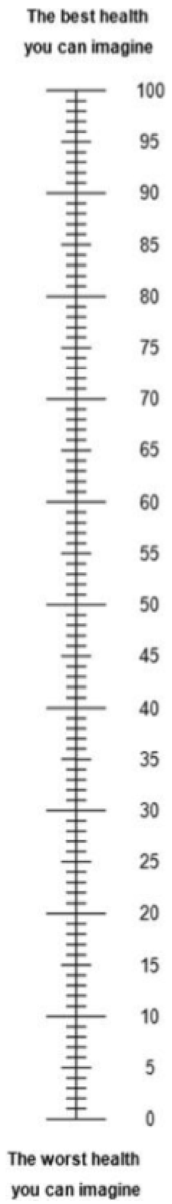
I have no pain or discomfort ☐
I have slight pain or discomfort ☐
I have moderate pain or discomfort ☐
I have severe pain or discomfort ☐
I have extreme pain or discomfort ☐

5. Anxiety/depression:
Please tick only one box

I am not anxious or depressed ☐
I am slightly anxious or depressed ☐
I am moderately anxious or depressed ☐
I am severely anxious or depressed ☐
I am extremely anxious or depressed ☐

6. In this section we would like to know how good or bad your health is TODAY. The next question consists of a scale which is numbered 0 to 100. 100 means the best health you can imagine. 0 means the worst health you can imagine.

Using the picture of the scale to guide you, please choose a value to indicate how your health is today, remembering 100 is the best possible health imaginable and 0 is the worst possible health imaginable.



100-95	☐
95-90	☐
90-85	☐
85-80	☐
80-75	☐
75-70	☐
70-65	☐
65-60	☐
60-55	☐
55-50	☐
50-45	☐
45-40	☐
40-35	☐
35-30	☐
30-25	☐
25-20	☐
20-15	☐
15-10	☐
10-5	☐
5-0	☐

7. Now please write the single number you marked on the scale in the box below, e.g. 62, 91, 74.

Office Use Only Self completed Yes ☐ No ☐

Study Number ☐☐☐ ☐☐☐☐

Worksite ☐☐☐

Confidential

Health, Lifestyle and Food Questionnaire

Thank you for taking the time to complete this questionnaire. Your time and information is greatly valued.

The questionnaire is organised into several sections on your general health, your dietary patterns at home and at work, your lifestyle patterns including physical activity, alcohol and smoking, your knowledge of food and your general sense of well-being.

Please read the question and instructions carefully and complete each section to the best of your ability.

It takes approximately 20-25 minutes to complete.

Instructions:

Please answer the following questions by filling in the appropriate boxes (as per example below) or by writing the answer in the space provided.

Self-completed example: **Are you male or female?** Male ■ Female ☐

1

In sections A, B and C we are interested to find out about you, your work life and your general health status.

Section A: About You

A1 Are you male or female? Male ☐ Female ☐

A2 What age are you? _____ years

A3 In what country were you born?

Ireland (Republic) ☐ → *Go to A5*
Ireland (NI) ☐
Other UK ☐
Other ☐ please specify________________________________ → *Go to A4*

A4 If not born in Ireland, when did you first move to Ireland? _______ **(year)**

A5 What is your ethnic or cultural background?

a) White: Irish ☐ Irish Traveller ☐ Any other white background ☐
b) Black or Black Irish: African ☐ Any other black background ☐
c) Asian or Asian Irish: Chinese ☐ Any other Asian background ☐
d) Other including mixed background ☐ Insert own description____________________________

A6 What is the highest level of education you have completed to date?

None/ primary not complete ☐
Primary or equivalent ☐
Intermediate/ Junior/ Group Certificate or equivalent ☐
Leaving Certificate or equivalent ☐
Diploma/ Certificate ☐
Primary degree ☐
Postgraduate/ Higher degree ☐

A7 What is your current marital status?

Single (never married) ☐ Cohabiting ☐ Married ☐
Separated ☐ Divorced ☐ Widowed ☐

A8 Are you at present:

Living alone ☐ Living with other people ☐

A9 Is your home?

Owned with mortgage ☐ Rented from local authority ☐ Rented privately ☐
Owned outright ☐ Other ☐

A10 How many individuals live in your household in each of the following categories?

Adults (18-65) ______
Adults (65+) ______
Children (14-17) ______
Children (5-13) ______
Children (<5) ______
Total ______ *[INT: TOTAL SHOULD EQUAL SUM OF PEOPLE IN EACH AGE GROUP]*

A11 How many children do you have?

None ☐ One ☐ Two ☐ Three ☐ Four or more ☐

A12 Are you responsible for purchasing the weekly grocery shopping (in general)?

Yes ☐ No ☐

A13 Are you responsible for cooking the daily meals in the household (in general)?

Yes ☐ No ☐

A14 Do you have any health or nutrition related qualifications?

Yes ☐ Please specify ______________________________
No ☐

Section B: About Your Work

B1 Indicate the type of position you hold in the company by filling in one of the following boxes:

Manager ☐
Supervisor ☐
Not a Manager/Not a supervisor employee ☐

B2 Indicate the type of job you hold in the company by filling in the box that best describes your position:

Human Resources	☐	Finance/Accounting	☐	Sales	☐
Purchasing	☐	Planning	☐	Quality	☐
Information Technology	☐	Engineering	☐	Production	☐
Maintenance	☐	Sanitation	☐	Administration	☐
Catering	☐	Other	☐		

If other, please specify______________________________

B3 How many hours per week do you work (including overtime)? ________hours

B4 What hours do you usually work?

Day-time (up to 8 hours)	☐	Day-time (12 hour shifts)	☐	Night-time (up to 8 hours)	☐
Night-shift (12 hours)	☐	Rotating shifts	☐	Other	☐

If other, please specify______________________________

B5 Is your work schedule best described as a regular schedule (roughly the same hours every day), a rotating schedule (e.g. working a shift some days and a night shift other days), or an irregular schedule (e.g., unpredictable hours controlled by situations or workload)?

Regular schedule ☐ Rotating schedule ☐ Irregular schedule ☐

B6 Are you an agency or company employee?

Agency employee ☐ Company employee ☐

B7 How many years have you been working in your current job for? ________years

Section C: General Health

C1 In comparison with an average person of your age, would you say your health is......?

Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor ☐

C2 Is your daily activity limited by a long term illness, health problem or disability?

Yes ☐ No ☐

C3 Have you ever been told by a doctor that you have any of the following?

	Yes	No	Didn't visit doctor
High blood pressure	☐	☐	☐
High cholesterol	☐	☐	☐
Heart Disease/ Angina/ Stroke	☐	☐	☐
Osteoporosis	☐	☐	☐

C4 Given your age and height, would you say that you are?

About the right weight ☐ Too heavy ☐ Too light ☐ Not sure ☐

C5 Are you actively trying to manage your weight?

Always ☐ Most of the time ☐ Sometimes ☐ Rarely ☐ Never ☐

C6 If you are actively trying to manage your weight, is it to...?

Lose weight ☐ Maintain your current weight ☐ Gain weight ☐

C7 (Women Only) Are you currently pregnant?
(Please feel free to skip this question if you wish)

Yes ☐ No ☐ Don't Know ☐

In sections D, E and F we are interested to find out about your usual dietary patterns at home and at work.

Section D: Food Life

D1 Do you follow any of the following diets? *(Please fill in all boxes that apply to you)*

Vegetarian ☐ Vegan ☐ Diabetic ☐
Gluten free ☐ Weight reducing ☐ Low cholesterol ☐
Do not follow a special diet ☐ → *Go to D3* Other ☐ ____________

D2 When did you first follow this/these diets...?

In the last year ☐ 1-5 years ago ☐ Over 5 years ago ☐

D3 What type of milk do you use most often?

None ☐ → *Go to D5* Whole milk/Full fat ☐
Low fat ☐ Skimmed ☐
Super/fortified ☐ Soya ☐
Other ☐
If other, please specify____________________

D4 How much milk do you drink each day?

None ☐ Less than half pint ☐ 250ml (half pint) ☐
568ml (one pint) ☐ One litre ☐ More than 1 litre ☐

D5 How often do you add salt to food while cooking?

Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never ☐

D6 How often do you add salt to food while at the table?

Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never ☐

D7 Do you take any vitamins, minerals or other food supplements currently?

Yes ☐ → *Go to D8* No ☐ → *Go to D26* Don't know ☐ → *Go to D26*

If you take any vitamins, minerals or other food supplements currently, please fill out the table below to outline the type and name of supplement(s) you take, how frequent you take them and when you started taking them:

Please tick the supplements you take		Name of supplement	How often do you take this supplement? (please tick 1): EVERY DAY	MOST DAYS	INFREQUENTLY	When did you start taking this supplement? (please tick 1): IN THE LAST YEAR	1-5 YEARS AGO	OVER 5 YEARS AGO
D8 Cod liver oil and other fish based supplements	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D9 Evening primrose oil type supplements	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D10 Vitamin C only	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D11 Other single vitamins NOT vitamin C	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D12 Vitamins A, C and D only	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D13 Vitamins with iron	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D14 Vitamin B6 and B12	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D15 Vitamin E	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D16 Calcium	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D17 Chromium	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D18 Magnesium	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D19 Zinc	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D20 Iron only	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D21 Non-prescribed folic acid only	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D22 Multivitamins and Multiminerals	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D23 Multivitamins, NO minerals	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D24 Minerals ONLY; NOT fluoride or iron ONLY	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								
D25 Other supplements (specify)	☐		☐	☐	☐	☐	☐	☐
Reason for taking this supplement:								

D26 For each of the 12 statements, please place an X in one box per statement which best represents your response (as per the example below)

Example:

Exercise is something....................................					
	Strongly Agree$_1$	**Agree$_2$**	**Neither Agree/Disagree$_3$**	**Disagree$_4$**	**Strongly Disagree$_5$**
I do frequently.	**X**				

Please complete statements **A – L**:

Healthy eating is something....................................					
	Strongly Agree$_1$	**Agree$_2$**	**Neither Agree/Disagree$_3$**	**Disagree$_4$**	**Strongly Disagree$_5$**
A. I do frequently					
B. I do automatically					
C. I do without having to consciously remember					
D. that makes me feel weird if I do not do it					
E. I do without thinking					
F. that would require effort not to do it					
G. that belongs to my (daily, weekly, monthly) routine					
H. I start doing before I realise I'm doing it					
I. I would find hard not to do					
J. I have no need to think about doing					
K. that's typically 'me'					
L. I have been doing for a long time					

Section E: Eating Habits at Work

E1 Have your eating habits at work changed over the past year?

Yes ☐ No ☐ → *Go to E4* Don't know ☐ → *Go to E4*

E2 If yes, are your eating habits:

Better ☐ Same ☐ → *Go to E4* Worse ☐ → *Go to E4* Don't Know ☐ → *Go to E4*

E3 If better, are you?

- Eating more fruit ☐
- Eating fewer calories ☐
- Eating less fat ☐
- Eating more fish ☐
- Eating more wholegrain/wholemeal products ☐
- Consuming less salt ☐
- Eating less sugar ☐
- Other ☐

If other, please specify ____________________________

E4 Has your use of salt changed over the past year at work?

Yes ☐ No ☐ → *Go to E7* Don't know ☐ → *Go to E7*

E5 If yes, did you: *(Please fill in all boxes that apply to you)*

- Reduce salt added to food at the table ☐
- Reduce salt added to food while cooking ☐
- Changed to low-salt ☐
- Stop adding salt to food at the table ☐
- Stop adding salt to food while cooking ☐
- Increased salt ☐

E6 If you reduced/changed your salt intake was this due to:

Medical Advice ☐ Personal Choice ☐ Not Applicable ☐

E7 Do your eating patterns at work influence your eating patterns at home?

Never ☐ Rarely ☐ Sometimes ☐ Most of the time ☐ Always ☐

Section F: Eating Environment at Work

F1 Overall how satisfied are you with the canteen food?

Very satisfied ☐ Satisfied ☐ Neither dissatisfied nor satisfied ☐
Dissatisfied ☐ Very dissatisfied ☐

F2 For each of the 4 statements, please place an X in one box per statement which best represents your response (as per the example below):

Example:

At my workplace....................................					
	Strongly Agree	Agree	Neither Agree/Disagree	Disagree	Strongly Disagree
I feel supported		X			

Please complete statements **A – D**:

At my workplace....................................					
	Strongly Agree	Agree	Neither Agree/Disagree	Disagree	Strongly Disagree
A. It's difficult to find fruit and vegetables					
B. It is easy to eat a healthy diet					
C. The menu has enough variety for me to choose meals					
D. The meals taste nice					

F3 Do you sometimes have difficulty eating and drinking during work hours, due to inadequate time?

Never ☐ Rarely ☐ Sometimes ☐ Most of the time ☐ Always ☐

In sections G, H, and I we are interested to find out about your usual lifestyle patterns including physical activity, alcohol and smoking.

Section G: Physical activity

G1 During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling? (If none, put 0 in box)

☐ Days **If none, put 0 in the box and go to G3**

G2 If yes, how much time did you usually spend doing vigorous physical activities on one of those days?

☐☐ Hrs ☐☐ Mins Don't know ☐ 9999

G3 Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? [Do not include walking]. (If none, put 0 in box)

☐ Days **If none, put 0 in the box and go to G5**

G4 If yes, how much time did you usually spend doing moderate physical activities on one of those days?

☐☐ Hrs ☐☐ Mins Don't know ☐ 9999

G5 Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place and any other walking that you do solely for recreation, sport, exercise and leisure.

During the last 7 days, on how many days did you walk for at least 10 minutes at a time? (If none, put 0 in box)

☐ Days **If none, put 0 in the box and go to G7**

G6 If yes, how much time did you usually spend walking on one of those days?

☐☐ Hrs ☐☐ Mins Don't know ☐ 9999

G7 Which of the following best describes your usual walking pace?
A slow pace ☐ A steady average pace ☐ A fairly brisk pace ☐ A fast pace – at least 4 mph ☐

G8 Is your job physically demanding?

Never ☐ Rarely ☐ Sometimes ☐ Most of the time ☐ Always ☐

G9 The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

During the last 7 days, how much time did you spend sitting on a week day?

☐☐ Hrs ☐☐ Mins Don't know ☐

Section H: Smoking

H1 Have you yourself smoked at least 100 cigarettes in your entire life? *[5 PACKS = 100 CIGARETTES]*

Yes ☐ No ☐ → *Go to SECTION I*

H2 Do you now smoke?

Yes ☐ No ☐ → *Go to H4*

If yes, how often do you smoke?

Every Day ☐ Some days ☐

H3 What do you smoke? (Please fill in all boxes that apply to you)

Pipe ☐

Cigarettes ☐

Cigars ☐ → *Go to H5*

H4 How long has it been since you last smoked?

Within the past month (anytime less than 1 month ago) ☐

Within the past 3 months (1 month but less than 3 months ago) ☐

Within the past 6 months (3 months but less than 6 months ago) ☐

Within the past year (6 months but less than 1 year ago) ☐

Within the past 5 years (1 year but less than 5 years ago) ☐

Within the past 10 years (5 years but less than 10 years ago) ☐

10 or more years ago ☐ → *Go to SECTION I*

H5 Are you currently?

Trying to quit ☐

Actively planning to quit ☐

Thinking about quitting but not planning to ☐

Not thinking about quitting ☐

H6 If I gave up smoking *(Please fill in all boxes that apply to you)*

	Yes	No	Unsure
My health would improve in the short term	☐	☐	☐
My health would benefit in the long term	☐	☐	☐
I would put on weight	☐	☐	☐
It would be harder to handle stress in my life	☐	☐	☐
I'd feel I had done something worthwhile	☐	☐	☐

Section I: Alcohol

I1 How often do you have a drink containing alcohol?

Never ☐ → *Go to SECTION J*
Monthly or less ☐
2-4 times a month ☐
2-3 times a week ☐
4 or more times a week ☐

I2 How long ago did you last have an alcoholic drink?

During the last week ☐
During the last month, but not in the last week ☐
Within the last three months, but not in the last month ☐
Within the last 12 months, but not in the last 3 months ☐
More than 12 months ago ☐
Never had alcohol beyond sips or tastes ☐ → *Go to SECTION J*

I3 Considering the last year, how **many drinks containing alcohol do you have on a typical day when you are drinking?** ____________________

A DRINK IS:

- *A HALF PINT OR A GLASS OF BEER, LAGER OR CIDER*
- *A SINGLE MEASURE OF SPIRITS (E.G. WHISKEY, VODKA, GIN*
- *A SINGLE GLASS OF WINE, SHERRY OR PORT*
- *BOTTLE OF ALCOPOPS (LONG NECK)]*

I4 How often do you have 6 or more [standard] drinks on one occasion?

Never ☐ Less than monthly ☐ Monthly ☐ Weekly ☐ Daily or almost daily ☐

I5 During the past 7 days how many standard drinks of any alcoholic beverage did you have each day?

Monday ______ Tuesday ______ Wednesday ______ Thursday ______
Friday ______ Saturday ______ Sunday ______

I6 How old were you when you started drinking? _________________

In section J, we are interested to find out about your knowledge of food.

Section J: Your nutrition knowledge

Advice from the Health Experts

The first few questions are about what advice you think experts are giving us

J1 Do you think health experts recommend that people should be eating more, the same amount, or less of these foods? (*fill in one box per food)*

	More	Same	Less	Not sure
Vegetables	☐	☐	☐	☐
Sugary foods	☐	☐	☐	☐
Meat	☐	☐	☐	☐
Starchy foods	☐	☐	☐	☐
Fatty foods	☐	☐	☐	☐
High fibre foods	☐	☐	☐	☐
Fruit	☐	☐	☐	☐
Salty Foods	☐	☐	☐	☐

J2 How many servings of fruit and vegetables a day do you think experts are advising people to eat? (One serving could be, for example, an apple or a handful of chopped carrots)

....

....

J3 Which fat do experts say is most important for people to cut down on? *(only fill one box)*

a) Monounsaturated fat ☐
b) Polyunsaturated fat ☐
c) Saturated fat ☐
d) Not sure ☐

J4 What version of dairy foods do experts say people should eat? *(only fill one box)*

a) Full fat ☐
b) Lower fat ☐
c) Mixture of full fat and lower fat ☐
d) Neither, dairy foods should be cut out ☐
e) Not sure ☐

Food Groups and Nutritional Content of Foods

This section is concerned with food groups and the nutritional content of foods.

J5 Do you think these foods are *high or low in added sugar*? (*fill in one box per food)*

	High	Low	Not sure
Bananas	☐	☐	☐
Unflavoured yoghurt	☐	☐	☐
Ice-cream	☐	☐	☐
Orange juice	☐	☐	☐
Tomato ketchup	☐	☐	☐
Tinned fruit in natural juice	☐	☐	☐

J6 Do you think these foods are *high or low in fat*? (*fill in one box per food)*

	High	Low	Not sure
Pasta (without sauce)	☐	☐	☐
Low fat spread	☐	☐	☐
Baked beans	☐	☐	☐
Lunch/sandwich meat	☐	☐	☐
(e.g. corned beef)	☐	☐	☐
Honey	☐	☐	☐
Meat pastry pie	☐	☐	☐
Nuts	☐	☐	☐
Bread	☐	☐	☐
Cottage cheese	☐	☐	☐
Polyunsaturated margarine	☐	☐	☐

J7 Do you think experts put these in the starchy foods group? (*fill in one box per food)*

	Yes	No	Not sure
Cheese	☐	☐	☐
Pasta	☐	☐	☐
Butter	☐	☐	☐
Nuts	☐	☐	☐
Rice	☐	☐	☐
Porridge	☐	☐	☐

J8 Do you think these foods are high or low in salt? (*fill in one box per food)*

	High	Low	Not sure
Sausages	☐	☐	☐
Pasta	☐	☐	☐
Kippers	☐	☐	☐
Red Meat	☐	☐	☐
Frozen vegetables	☐	☐	☐
Cheese	☐	☐	☐
Tinned Soup	☐	☐	☐

J9 Do you think these foods are *high or low in protein*? (*fill in one box per food)*

	High	Low	Not sure
Chicken	☐	☐	☐
Cheese	☐	☐	☐
Fruit	☐	☐	☐
Baked beans	☐	☐	☐
Butter	☐	☐	☐
Cream	☐	☐	☐

J10 Do you think these foods are *high or low in fibre/roughage*? (*fill in one box per food)*

	High	Low	Not sure
Cornflakes	☐	☐	☐
Bananas	☐	☐	☐
Eggs	☐	☐	☐
Red meat	☐	☐	☐
Broccoli	☐	☐	☐
Nuts	☐	☐	☐
Fish	☐	☐	☐
Baked potatoes with skins	☐	☐	☐
Chicken	☐	☐	☐
Baked beans	☐	☐	☐

J11 Do you think these fatty foods are *high or low in saturated fat*? (*fill in one box per food)*

	High	Low	Not sure
Mackerel	☐	☐	☐
Whole milk	☐	☐	☐
Olive oil	☐	☐	☐
Red meat	☐	☐	☐
Broccoli	☐	☐	☐
Sunflower margarine	☐	☐	☐
Chocolate	☐	☐	☐

J12 Some foods contain a lot of fat but no cholesterol

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J13 Do you think experts call these a healthy alternative to red meat? (*fill in one box per food)*

	Yes	No	Not sure
Liver pate	☐	☐	☐
Lunch/sandwich meat	☐	☐	☐
(e.g. corned beef)	☐	☐	☐
Baked beans	☐	☐	☐
Nuts	☐	☐	☐
Low fat cheese	☐	☐	☐
Quiche	☐	☐	☐

J14 A glass of unsweetened fruit juice counts as a helping of fruit

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J15 Saturated fats are mainly found in: *(only fill one box)*

a) Vegetable oils ☐
b) Dairy products ☐
c) Both a) and b) ☐
d) Not sure ☐

J16 Brown sugar is a healthy alternative to white sugar

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J17 There is more protein in a glass of whole milk than in a glass of skimmed milk

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J18 Polyunsaturated margarine contains less fat than butter

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J19 Which of these breads contain the most vitamins and minerals? *(only fill one box)*

a) White ☐
b) Brown ☐
c) Wholegrain ☐
d) Not sure ☐

J20 Which do you think is higher in calories: butter or regular margarine? *(only fill one box)*

a) Butter ☐
b) Regular Margarine ☐
c) Both the same ☐
d) Not sure ☐

J21 A type of oil which contains mostly monounsaturated fat is: *(only fill one box)*

a) Coconut oil ☐
b) Sunflower oil ☐
c) Olive oil ☐
d) Palm oil ☐
e) Not sure ☐

J22 There is more calcium in a glass of whole milk than a glass of skimmed milk

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J23 Which one of the following has the most calories for the same weight? *(only fill one box)*

a) Sugar ☐
b) Starchy foods ☐
c) Fibre/roughage ☐
d) Fat ☐
e) Not sure ☐

J24 Harder fats contain more: *(only fill one box)*

a) Monounsaturates ☐
b) Polyunsaturates ☐
c) Saturates ☐
d) Not sure ☐

J25 Polyunsaturated fats are mainly found in: *(only fill one box)*

a) Vegetable oils ☐
b) Dairy products ☐
c) Both a) and b) ☐
d) Not sure ☐

Food Choice

The next few items are about choosing foods. Please answer what is being asked and not whether you like or dislike the food!

For example, suppose you were asked..................
'If a person wanted to cut down on fat, which cheese would be best to eat?'

(a) Cheddar cheese
(b) Camembert
(c) Cream cheese
(d) Cottage cheese

If you didn't like cottage cheese, but knew it was the right answer, you would still fill in the box for cottage cheese.

J26 What is the best choice for a low fat, high fibre snack? *(only fill one box)*

a) Diet strawberry yoghurt ☐
b) Raisins ☐
c) Muesli bar ☐
d) Wholemeal crackers and cheddar cheese ☐

J27 What is the best choice for a low fat, high fibre light meal? *(only fill one box)*

a) Grilled chicken ☐
b) Cheese on wholemeal toast ☐
c) Beans on wholemeal toast ☐
d) Quiche ☐

J28 Which kind of sandwich is healthier? *(only fill one box)*

a) Two thick slices of bread with a thin slice of cheddar cheese filling ☐
b) Two thin slices of bread with a thick slice of cheddar cheese filling ☐

J29 Many people eat spaghetti bolognese (pasta with tomato and meat sauce). Which option is healthier? *(only fill one box)*

a) A large amount of pasta with a little sauce on top ☐
b) A small amount of pasta with a lot of sauce on top ☐

J30 If a person wanted to reduce the amount of fat in their diet, which would be the best choice? *(only fill one box)*

a) Steak, grilled ☐
b) Sausages, grilled ☐
c) Turkey, grilled ☐
d) Pork chop, grilled ☐

J31 If a person wanted to reduce the amount of fat in their diet, but didn't want to give up chips, which one would be the best choice? *(only fill one box)*

a) Thick cut chips ☐
b) Thin cut chips ☐
c) Crinkle cut chips ☐

J32 If a person felt like something sweet, but was trying to cut down on sugar, which would be the best choice? *(only fill one box)*

a) Honey on toast ☐
b) A cereal snack bar ☐
c) Plain digestive biscuit ☐
d) Banana with plain Yoghurt ☐

J33 Which of these would be the healthiest pudding? *(only fill one box)*

a) Baked apple ☐
b) Strawberry yoghurt ☐
c) Wholemeal crackers and cheddar cheese ☐
d) Carrot cake with cream cheese topping ☐

J34 Which cheese would be the best choice as a lower fat option? *(only fill one box)*

a) Plain cream cheese ☐
b) Edam ☐
c) Cheddar ☐
d) Stilton ☐

J35 If a person wanted to reduce the amount of salt in their diet, which would be the best choice? *(only fill one box)*

a) Ready-made frozen shepherd's pie ☐
b) Gammon with pineapple ☐
c) Mushroom omelette ☐
d) Stir fry vegetables with soy sauce ☐

J36 Which one of these would be the right portion size for a serving of cheese? *(only fill one box)*

a) 1 match-box size portion ☐
b) 2 match-box portion ☐
c) Palm of the hand ☐

J37 Which one of these would be the right portion size for a serving of peanut butter? *(only fill one box)*

a) 1 teaspoon (5ml) ☐
b) 2 teaspoons (10ml) ☐
c) 3 teaspoons (15ml) ☐

Diet and Disease

This section is about the relationship between diet and health problems or diseases.

J38.1 Are you aware of any major health problems or diseases that are related to a low intake of fruit and vegetables

a) Yes ☐
b) No ☐
c) Not sure ☐

J38.2 If yes, what diseases or health problems do you think are related to a *low intake of fruit and vegetables?*

....
....

J39.1 Are you aware of any major health problems or diseases that are related to a *low intake of fibre?*

a) Yes ☐
b) No ☐
c) Not sure ☐

J39.2 If yes, what diseases or health problems do you think are related to *a low intake of fibre*?

....
....

J40.1 Are you aware of any major health problems or diseases that are related to *how much sugar* people eat?

a) Yes ☐
b) No ☐
c) Not sure ☐

J40.2 If yes, what diseases or health problems do you think are related to sugar?

....
....

J41.1 Are you aware of any major health problems or diseases that are related to *how much salt or sodium* people eat?

a) Yes ☐
b) No ☐
c) Not sure ☐

J41.2 If yes, what diseases or health problems do you think are related to salt?

....
....

J42.1 Are you aware of any major health problems or diseases that are related to the *amount of fat* people eat?

a) Yes ☐
b) No ☐
c) Not sure ☐

J42.2 If yes, what diseases or health problems do you think are related to fat?

....
....

J43 Do you think these help to reduce the chances of getting certain kinds of cancer? *(answer each one)*

	Yes	No	Not sure
Eating more fibre	☐	☐	☐
Eating less sugar	☐	☐	☐
Eating less fruit	☐	☐	☐
Eating less salt	☐	☐	☐
Eating more fruit & vegetables	☐	☐	☐
Eating less preservatives/ additives	☐	☐	☐

J44 Do you think these help prevent heart disease? (*answer each one*)

	Yes	No	Not sure
Eating more fibre	☐	☐	☐
Eating less saturated fat	☐	☐	☐
Eating less salt	☐	☐	☐
Eating more fruit and vegetables	☐	☐	☐
Eating less preservatives/additives	☐	☐	☐

J45 Which one of these is more likely to raise people's blood cholesterol level? *(only fill one box)*

Antioxidants ☐
Polyunsaturated Fats ☐
Saturated Fats ☐
Cholesterol in the diet ☐
Not sure ☐

J46 Have you heard of antioxidant vitamins?

a) Yes ☐
b) No ☐

J47 If YES to question J46, do you think these vitamins are antioxidant vitamins? (*answer each one*)

	Yes	No	Not sure
Vitamin A	☐	☐	☐
B Complex Vitamins	☐	☐	☐
Vitamin C	☐	☐	☐
Vitamin D	☐	☐	☐
Vitamin E	☐	☐	☐
Vitamin K	☐	☐	☐

That is the end of the questionnaire!

Your contribution to this research is greatly appreciated.

Office Use Only Self completed Yes ☐ No ☐

Study Number ☐☐☐ ☐☐☐☐

Worksite ☐☐☐

Confidential

Food Frequency Questionnaire

Thank you for taking the time to complete this questionnaire. Your time and information is greatly valued.

The questionnaire is organised into 9 different food categories and you will be asked to record your average frequency of consumption of each food item over the last year.

YOUR DIET OVER THE LAST YEAR

For each food there is an amount shown, either what we think is a "medium serving" or a common household unit such as a slice or teaspoon. Please put a tick in the box to indicate how often, on average, you have eaten the specified amount of each food, to the nearest whole number during the past year i.e. from when you receive this questionnaire to the same month the previous year. Please estimate your average food use as best you can. Please answer every question, do not leave ANY lines blank.

Please read the questions and instructions carefully and complete each section to the best of your ability.

It takes approximately 20 minutes to complete.

EXAMPLES:

The following are examples on how to estimate how often and how much bread and potatoes you ate over the past year. Please estimate your food intake for all foodstuffs in the same way. Potatoes: If you have eaten a medium serving of potatoes 3 times per week over the past year put a tick in the box "2-4 per week". If you think you usually eat more or less than a medium serving please try to estimate which box suits best.

AVERAGE USE LAST YEAR									
Potatoes, Rice and Pasta (medium serving)	Never or less than once per month	1-3 per month	Once per week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Boiled, instant or jacket potatoes	☐	☐	☐	☒	☐	☐	☐	☐	☐

For white bread a medium serving is one medium sized slice. Therefore if you usually eat 1 medium slice 4 or 5 times per day, you should put a tick in the column headed "4-5 per day". If you eat 2 medium slices 4 or 5 times per day, then you should put a tick in the column "6+ per day".

AVERAGE USE LAST YEAR									
BREAD AND SAVOURY BISCUITS (One slice or one biscuit)	Never or less than once per month	1-3 per month	Once per week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
White bread and rolls (including ciabatta and panini bread)	☐	☐	☐	☐	☐	☐	☐	☒	☐

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	AVERAGE USE LAST YEAR								
MEAT, FISH AND POULTRY (Medium serving – the size of a deck of cards)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Beef: roast	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beef: steak	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beef: mince	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beef: stew	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beef Burger (1 burger)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pork: roast	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pork: chops	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pork: slices/escalopes	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lamb: roast	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lamb: chops	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lamb: stew	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chicken portion or other poultry e.g. turkey: Roast	☐	☐	☐	☐	☐	☐	☐	☐	☐
Breaded chicken, chicken nuggets, chicken burger	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bacon	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ham	☐	☐	☐	☐	☐	☐	☐	☐	☐
Corned beef, Spam, Luncheon meats	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sausages, Frankfurters (1 sausage)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Savoury pies (e.g. meat pie, pork pie, steak & kidney pie, sausage rolls)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Liver, heart, kidney	☐	☐	☐	☐	☐	☐	☐	☐	☐
Liver paté	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fish fried in batter, as in fish and chips	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fish fried in breadcrumbs	☐	☐	☐	☐	☐	☐	☐	☐	☐
Oven baked/grilled fish (in breadcrumbs or batter)	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line

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	AVERAGE USE LAST YEAR								
MEAT, FISH AND POULTRY (Medium serving – the size of a deck of cards)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Fish fingers/fish cakes	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other white fish, fresh or frozen (e.g. cod, haddock, plaice, sole, halibut, coli)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Oily fish, fresh or canned (e.g. mackerel, kippers, tuna, salmon, sardines, herring)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shellfish (e.g. crab, prawns, mussels)	☐	☐	☐	☐	☐	☐	☐	☐	☐

	AVERAGE USE LAST YEAR								
BREAD AND SAVOURY BISCUITS (One slice or one biscuit)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
White bread and rolls (including ciabatta and pannini bread)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brown bread and rolls	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wholemeal bread and rolls	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cream crackers, cheese biscuits	☐	☐	☐	☐	☐	☐	☐	☐	☐
Crisp bread, e.g. Ryvita	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pancakes, muffins, oatcakes	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line

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	AVERAGE USE LAST YEAR								
CEREALS (One medium sized bowl)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Porridge, Readybrek									
All Bran, Weetabix, Shredded Wheat									
Branflakes, Bran Buds									
Cornflakes, Rice Krispies									
Muesli (e.g. Country Store, Alpen, sugar coated									
Sugar Coated Cereals (e.g. Frosties, Crunchy Nut Cornflakes, Crunchy Sugar Coated Muesli)									

	AVERAGE USE LAST YEAR								
POTATOES, RICE AND PASTA (Medium serving – about a cupful)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Boiled, instant or jacket potatoes									
Mashed potatoes									
Chips									
Roast potatoes									
Potato salad									
White rice									
Brown rice									
White/yellow or green pastas (e.g. spaghetti, macaroni, noodles)									
Wholemeal pasta									

Please check that you put a cross (X) on every line

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	AVERAGE USE LAST YEAR								
POTATOES, RICE AND PASTA (Medium serving – about a cupful)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Lasagne (meat based)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lasagne (vegetarian)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Moussaka	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pizza	☐	☐	☐	☐	☐	☐	☐	☐	☐
Macaroni Cheese	☐	☐	☐	☐	☐	☐	☐	☐	☐

	AVERAGE USE LAST YEAR								
DAIRY PRODUCTS AND FATS	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Cream (Tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Full-fat yoghurt or Greek-style yoghurt (125g carton)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Low-fat yoghurt, fromage frais (125g carton)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dairy desserts (125g carton)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cheddar cheese (medium serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brie, Edam type cheese (medium serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Low-fat cheddar cheese (medium serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cottage cheese, cream cheese, low-fat soft cheese (medium serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Eggs as boiled, fried, scrambled, poached (one)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Quiche (medium serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Light salad cream or light mayonnaise (tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Salad cream, mayonnaise (Tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line 6

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DAIRY PRODUCTS AND FATS	AVERAGE USE LAST YEAR Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
French dressing (tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other salad dressing (Tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐

THE FOLLOWING ON BREAD OR VEGETABLES	Never or less than once per month	1-3 per mth	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Butter (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lite Butter e.g. Dawn Lite, Connacht Gold (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sunflower margarine e.g. Flora (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Low-fat margarine (e.g. Low-low)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cholesterol Lowering Spreads e.g. Flora Pro Active, Dairy Gold Heart (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cream & Vegetable Oil spread e.g. Golden Pasture, Kerrymaid, Dairy Gold – teaspoon	☐	☐	☐	☐	☐	☐	☐	☐	☐
Olive oil spread e.g. Golden Olive (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐

FRUIT (1 Fruit or medium serving)	AVERAGE USE LAST YEAR Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Apples	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pears	☐	☐	☐	☐	☐	☐	☐	☐	☐
Oranges, Satsumas, Mandarins	☐	☐	☐	☐	☐	☐	☐	☐	☐
Grapefruit	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bananas	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line

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	AVERAGE USE LAST YEAR								
FRUIT (1 Fruit or medium serving)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Grapes	☐	☐	☐	☐	☐	☐	☐	☐	☐
Melon	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peaches, Plums, Apricot	☐	☐	☐	☐	☐	☐	☐	☐	☐
Strawberries, Raspberries, Kiwi fruit	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tinned fruit	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dried fruit e.g. raisins	☐	☐	☐	☐	☐	☐	☐	☐	☐
Frozen fruit	☐	☐	☐	☐	☐	☐	☐	☐	☐

	AVERAGE USE LAST YEAR								
VEGETABLES Fresh, frozen or tinned (Medium serving – 2 tablespoons)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Carrots	☐	☐	☐	☐	☐	☐	☐	☐	☐
Spinach	☐	☐	☐	☐	☐	☐	☐	☐	☐
Broccoli, Spring Greens, Kale	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brussel Sprouts	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cabbage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peas	☐	☐	☐	☐	☐	☐	☐	☐	☐
Green Beans, Broad Beans, Runner Beans	☐	☐	☐	☐	☐	☐	☐	☐	☐
Marrow, Courgettes	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cauliflower	☐	☐	☐	☐	☐	☐	☐	☐	☐
Parsnips, Turnips	☐	☐	☐	☐	☐	☐	☐	☐	☐
Leeks	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line

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	AVERAGE USE LAST YEAR								
VEGETABLES Fresh, frozen or tinned (Medium Serving – 2 tablespoons)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Onions	☐	☐	☐	☐	☐	☐	☐	☐	☐
Garlic	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mushrooms	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sweet Peppers	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beansprouts	☐	☐	☐	☐	☐	☐	☐	☐	☐
Green salad, Lettuce	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cucumber, Celery	☐	☐	☐	☐	☐	☐	☐	☐	☐
Watercress	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tomatoes	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sweetcorn	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beetroot	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coleslaw	☐	☐	☐	☐	☐	☐	☐	☐	☐
Avocado	☐	☐	☐	☐	☐	☐	☐	☐	☐
Baked Beans	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dried lentils, beans, peas	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tofu, Soya Meat, TVP, Vegeburger	☐	☐	☐	☐	☐	☐	☐	☐	☐

	AVERAGE USE LAST YEAR								
SWEETS AND SNACKS (Medium serving)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Chocolate coated sweet biscuits e.g. digestive (one)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Plain sweet biscuits e.g. Marietta, digestives, rich tea (one)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cakes e.g. fruit, sponge	☐	☐	☐	☐	☐	☐	☐	☐	☐
Scones, flapjacks	☐	☐	☐	☐	☐	☐	☐	☐	☐
Buns, pastries e.g. croissants, doughnuts	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line

	AVERAGE USE LAST YEAR								
SWEETS AND SNACKS (Medium serving)	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Fruit pies, tarts, crumbles	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sponge puddings	☐	☐	☐	☐	☐	☐	☐	☐	☐
Milk puddings e.g. rice, custard, trifle	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ice cream, choc ices, Frozen desserts	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chocolates, singles or squares	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sweets, toffees, mints	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sugar added to tea coffee, cereal (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sugar substitute e.g. canderel added to tea coffee, cereal (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Crisps or other packet snacks	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peanuts or other nuts	☐	☐	☐	☐	☐	☐	☐	☐	☐

	AVERAGE USE LAST YEAR								
SOUPS, SAUCES AND SPREADS	Never or less than once per mth	1-3 per mth	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Vegetable soups: Homemade/Fresh (1 bowl)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Vegetable soups: Tinned/packet (1 bowl)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Meat or cream soups: Homemade/Fresh (1 Bowl)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Meat or cream soups: Tinned/packet (1 bowl)	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line

SOUPS, SAUCES AND SPREADS	AVERAGE USE LAST YEAR								
	Never or less than once per mth	1-3 per mth	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Sauces e.g. white sauce, cheese sauce, gravy (Tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tomato based sauces e.g. pasta sauces	☐	☐	☐	☐	☐	☐	☐	☐	☐
Curry-type sauces	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pickles, chutney (Tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Marmite, Bovril (Tablespoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Jam, marmalade, honey, syrup (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peanut butter (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐

DRINKS	AVERAGE USE LAST YEAR								
	Never or less than once per month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Tea (cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coffee instant (cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coffee, decaffeinated (cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coffee whitener e.g. coffee-mate (teaspoon)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cocoa, Hot Chocolate (cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Horlicks, Ovaltine (cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wine (glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beer, Larger or Cider (half pint)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Alcopops e.g. Bacardi Breezer (bottle)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Port, Sherry, Vermouth, Liqueurs (glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please check that you put a cross (X) on every line

Appendix 5: Published papers